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THE

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AND

Journal of The Mineralogical Society.

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EDITED BY L. J. SPENCER, M.A.

ASSISTED BY A COMMITTEE OF COUNCIL.

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1910.

EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, June 15, 1909, *at* 7.30 *p.m.*

PRINCIPAL MIERS, D.Sc., F.R.S., President, in the Chair.

The death of Dr. A. Brezina, Honorary Member, was announced, and the President was requested to write a letter of condolence to the widow and family.

The following changes in the list of Officers and Council were approved for recommendation to the members of the Society:—

President. Prof. W. J. Lewis, in place of Principal H. A. Miers.

Vice-President. Prof. H. L. Bowman, in place of Prof. W. J. Lewis.

General Secretary. Dr. G. T. Prior, in place of Mr. L. Fletcher.

Ordinary Members of Council. Messrs. C. G. Cullis, J. H. Collins, J. W. Evans, and J. A. Howe, in place of Messrs. J. J. Beringer, H. B. Hartley, G. T. Prior, and A. P. Young.

The report of the Committee appointed to consider the vacancies in the list of Honorary Members was presented and considered.

Proposals with regard to presentation and exchange of the Magazine were considered.

GENERAL MEETING.

Held in the Apartments of the Geological Society, June 15, 1909, *at* 8 *p.m.*

PRINCIPAL MIERS, D.Sc., F.R.S., President, in the Chair.

Eighteen Members and two Visitors were present.

The following papers were read:—

1. On Carnotite and an associated mineral complex from South Australia: by Mr. T. Crook and Mr. G. S. Blake (p. 271).

2. On the species Pilolite, and the examination of a specimen from China: by Mr. G. S. Whitby (communicated by the editor) (p. 294).

3. On Phenakite from Brazil: by Dr. G. F. Herbert Smith.

4. On the occurrence of Gyrolite in County Antrim: by Mr. F. N. A. Reischmann (p. 288).

Specimens were shown in illustration of each of the above papers, and Prof. H. L. Bowman also exhibited and described remarkable specimens of Zincite and Cassiterite: further, Dr. Herbert Smith exhibited and described a form of refractometer designed by him for the determination of the salinity of water.

EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, November 16, 1909, *at* 5 *p.m.*

Professor W. J. Lewis, M.A., F.R.S., Vice-President, in the Chair.

Mr. Thomas Knowles, B.A., B.Sc., School of Mines, Camborne, was elected an Ordinary Member of the Society.

Prof. Salvador Calderón, of the University of Madrid, Prof. Giuseppe Cesàro, of the University of Liège, and Prof. Friederich Becke, of the University of Vienna, were elected Honorary Members of the Society.

The following were selected as the dates of meeting for the year 1910: Tuesdays, January 25, March 15, June 7, and November 15, the last to be the Anniversary Meeting.

The Annual Report of Council, drafted by Dr. Prior, was read and approved.

ANNIVERSARY MEETING.

Held in the Apartments of the Geological Society, November 16, 1909, *at* 5.30 *p.m.*

Professor W. J. Lewis, M.A., F.R.S., Vice-President, in the Chair.

Twenty-nine Members were present.

The elections of Mr. T. Knowles as Ordinary Member, and of Professors Calderón, Cesàro, and Becke as Honorary Members were confirmed.

The scrutineers reported that thirty-five voting papers had been returned, and that the list as nominated by the Council was approved, namely:—

President. Prof. W. J. Lewis, M.A., F.R.S.
Vice-Presidents. Prof. H. L. Bowman, M.A., D.Sc., F.G.S.
A. E. H. Tutton, M.A., D.Sc., F.R.S.
Treasurer. W. Phipson Beale, K.C., M.P., F.G.S., F.C.S.
General Secretary. G. T. Prior, M.A., D.Sc., F.G.S.
Foreign Secretary. Prof. W. W. Watts, M.A., Sc.D., F.R.S.
Editor of the Journal. L. J. Spencer, M.A., F.G.S.

Ordinary Members of Council.

W. Barlow, F.R.S.
G. Barrow, F.G.S.
J. H. Collins, F.G.S.
C. G. Cullis, D.Sc., F.G.S.
J. W. Evans, LL.B., D.Sc., F.G.S.
F. N. A. Fleischmann, M.A., F.C.S.
H. Hilton, M.A.
J. A. Howe, B.Sc., F.G.S.
A. Hutchinson, M.A., Ph.D., F.G.S.
B. Kitto, F.I.C., F.G.S.
Arthur Russell.
G. F. H. Smith, M.A., D.Sc., F.G.S.

The following ANNUAL REPORT OF COUNCIL was read:—

During the past year four meetings have been held (by kind permission) in the Apartments of the Geological Society, Burlington House, W., at which twenty-four papers were read. One number of the Journal (No. 70, published in July) has been issued during the Session. It contains nine papers, one of them, 'On a new method for studying the optical properties of crystals,' being by the late Dr. Henry Clifton Sorby, the first President of the Society.

During the Session 1908–9 the Society has lost by resignation one Ordinary Member, and by death a Past-President, Mr. Wilfrid H. Hudleston, and two Honorary Members, Dr. A. Brezina and Prof. Fredrik Johan Wiik; while five Ordinary Members have been elected. The total number of members on November 15, 1909, was 128; of whom 16 are Honorary Members. Of the Ordinary Members fifty-one have compounded for their annual subscription.

As regards the financial position of the Society, the balance-sheet of the year ending December 31, 1908, shows that the assets (exclusive of the Library and the stock of the Journal) amounted to £709 10*s.* 9*d.* and the liabilities to £12 12*s.* 2*d.* The value of the Stock invested in the names of the Trustees of the Society was on that date £630, corresponding to £12 7*s.* 1*d.* for each Life Member.

The Council has to congratulate the Society on its continued scientific activity and financial prosperity.

On the motion of Dr. Tutton, seconded by Dr. Hugo Müller, the Report was adopted.

A vote of thanks to the Council of the Geological Society for permission to meet in the Apartments of the Society was carried.

A hearty vote of thanks proposed by the President to the retiring Secretary, Mr. Fletcher, was carried with acclamation. Mr. Fletcher in his reply gave an interesting account of his experiences as Secretary of the Society during the past twenty-one years.

The following papers were then read :—

1. On an occurrence of native Copper with tin-ore in the Federated Malay States : by Mr. J. B. Scrivenor (p. 299).

2. On a Meteoric Stone from Simondium, Cape Colony : by Dr. G. T. Prior (p. 312).

3. On the occurrence of Alstonite and Ullmannite (a species new to Britain) in a Barytes-Witherite vein at the New Brancepeth Colliery near Durham : by Mr. L. J. Spencer (p. 302).

4. On Sartorite and other minerals from the Binnenthal : by Prof. W. J. Lewis.

A pocket sclerometer was exhibited by Mr. C. J. Woodward.

THE MINERALOGICAL MAGAZINE

AND

JOURNAL OF

THE MINERALOGICAL SOCIETY.

No. 71. March, 1910. Vol. XV.

On Carnotite and an associated mineral complex from South Australia.[1]

By T. Crook, F.G.S., and G. S. Blake, B.Sc., F.C.S.

Scientific and Technical Department, Imperial Institute.

[Read June 15, 1909.]

THIS paper gives the results of an investigation at the Imperial Institute of a carnotite-bearing specimen received from South Australia.

The material represented by the specimen is described by Mr. H. Y. L. Brown,[2] Government Geologist of South Australia, as occurring about 2 miles SSW. of Teesdale's dam and about 20 miles ESE. of Olary railway station.[3] He remarks: 'The ore occurs as yellow and greenish-yellow incrustations and powder on the faces, joints, and cavities of a lode formation, which consists of magnetic titaniferous iron, magnetite, &c., and quartz in association with black mica (biotite) . . . . . The outcrops traverse metamorphic gneissic micaceous granite and granite schist, into which dykes of granite and diorite have been intruded.'

During 1906, Mr. W. S. Chapman, analyst at the South Australian School of Mines, analysed a bulk sample of the lode-stuff and found that it contained 0·28 per cent. of uranium oxide (U_3O_8). The amount of the yellow incrustation collected is stated to have been insufficient for a complete analysis; but it was found to contain 60 per cent. of

[1] Communicated by permission of the Director of the Imperial Institute.

[2] H. Y. L. Brown, 'Record of the Mines of South Australia.' 4th Edition, Adelaide, 1908, p. 361.

[3] The exact locality is referred to by Mr. Mawson (see below) as Radium Hill.

uranium oxide and a considerable amount of vanadic oxide, and it was inferred that the yellow incrustation consisted of the substance known as carnotite.

The material was subsequently examined by Mr. D. Mawson, Professor E. H. Rennie, and Dr. W. T. Cooke, of the Adelaide University. After a mineralogical examination of the lode-stuff, Mr. Mawson concluded that it contained several new minerals.[1] To one of these he gave the name 'davidite', after Professor T. W. Edgeworth David; the others he left unnamed pending the completion of the chemical analyses by Drs. Rennie and Cooke. The latter confirmed the identity of the carnotite, but were unable at the time to give quantitative analytical results for the supposed new minerals, though they hoped to do so at a later date.[2] The results stated by Mr. Mawson are quite inadequate for the purpose of establishing the existence of any new mineral in the lode-stuff; and no further results appear to have been published either by him or by Drs. Rennie and Cooke.

A massive block of the lode-stuff, weighing about 16 lb., has been examined by us. In a general way, it corresponds very closely with the Government Geologist's description already quoted. The bulk of the material consists of the ingredient referred to by him as 'magnetic titaniferous iron, magnetite, &c.', which on superficial examination gives one the impression that it is homogeneous, though here and there patches of rutile can be seen on its broken surfaces by examining closely with a pocket-lens. In lustre it is much duller than ilmenite, and in general appearance it approaches massive varieties of titaniferous magnetite; but certain small portions of the mass were observed to have the brilliant lustre of ordinary ilmenite. Coarse, irregular plates of biotite were present in scattered patches, and the block was bordered on one side by a layer of coarsely granular quartz.

The constituent described as carnotite was present in the small cracks and cavities of the block, but the total amount was very small. Ferruginous and earthy-looking decomposition products were also present, and the whole block had a brownish-red, much-weathered exterior.

The portions of the specimen specially examined by us were:—

(1) The carnotite.

[1] D. Mawson, 'On certain new mineral species associated with carnotite in the radio-active ore body near Olary.' Trans. and Proc. Royal Society of South Australia, 1906, vol. xxx, p. 188.

[2] E. H. Rennie and W. T. Cooke, 'Preliminary analytical notes on the minerals described in the preceding paper.' Ibid., p. 193.

(2) The complex material which formed the bulk of the specimen, and which appeared from a preliminary mineralogical examination to consist essentially of an intimate admixture of ilmenite, rutile, and magnetite, the ilmenite predominating.

(1) The Carnotite.

a. Chemical composition:—As no complete analysis had been made of the South Australian carnotite, it was considered advisable that this should be attempted, in order to ascertain if its identity could be fully established. For this purpose about 12 lb. of the lode-stuff was broken into coarse fragments, and as much as possible of the yellow powder collected. It was found impossible to collect sufficient in a clean state to carry out an analysis. The yellow crust was therefore scraped from the fragments, in order to obtain as much as possible. The amount thus obtained weighed about 0·9 gram; but it was very impure, containing a considerable amount of biotite, and other ingredients from the general mass, as well as some of the ferruginous and earthy-looking decomposition products already referred to as occurring in the cracks and cavities of the specimen. It was gently ignited, re-weighed, and then digested with dilute nitric acid, to dissolve the yellow powder. The amount thus dissolved was 0·22 gram, and it was on this that the analysis had to be made. The analysis of this soluble portion of the ignited yellow powder, &c., gave the following result:—

U_3O_8	...	47·8 per cent.
V_2O_5	...	16·8
P_2O_5	...	trace
Al_2O_3	...	5·7
Fe_2O_3	...	19·4
CaO	...	1·0
MgO	...	trace
K_2O	...	5·2
Na_2O	...	1·8
PbO	...	1·3
		99·0

It may be assumed that the ferric oxide and alumina represent impurity scraped from the specimen along with the yellow crust. If we re-calculate on this assumption, allowing 5 per cent. of water, we get the following result; beside which is placed, for the purpose of com-

parison, a re-calculated analysis by Dr. W. F. Hillebrand on carnotite from Copper Prince claim, Roc Creek, Montrose Co., Colorado.[1]

	South Australia.	Colorado.
U_3O_8	60·8	61·53 (UO_3).
V_2O_5	21·4	20·72
P_2O_5	trace	0·90
CaO	1·3	3·03
BaO (SrO) ...	—	1·03
MgO	trace	0·25
K_2O	6·6	7·31
Na_2O	2·3	0·15
PbO	1·7	—
H_2O	5·0	5·08
	99·1	100·00

It is unfortunate that there was not sufficient of the South Australian yellow powder to enable a more complete and satisfactory analysis to be made. The analysis here given is an obviously imperfect one, but it is perhaps permissible to infer that a comparison of results such as that given above, establishes the chemical identity of the South Australian and Colorado carnotites. This inference is strengthened by the fact that Mr. Chapman, working on a fairly clean specimen of the South Australian yellow powder, found 60 per cent. of uranoso-uranic oxide (U_3O_8).

b. Physical characters.—The South Australian carnotite has in part a powdery consistency, and when clean appears to have a canary-yellow colour. When highly magnified under the microscope, the powder is seen to consist of innumerable, very small, four-sided crystal-plates and platy aggregates, which are more or less transparent, and of a fine yellow colour. The platy crystals forming the loose yellow powder observed in the cavities were of variable size, some of them being about 0·03 mm. across; but the average length and width observed was well below 0·01 mm. These plates are rhombic in shape, and have well-defined edges. Some have grown irregularly, but even when irregular in shape they usually show serrated edges, the angles of the serrations having the same values as those of the regular plates. The averages of numerous readings give 78° for the acute angles, and 102° for the obtuse angles of

[1] W. F. Hillebrand and F. L. Ransome, 'On carnotite and associated vanadiferous minerals in western Colorado.' Amer. Journ. Sci., 1900, ser. 4, vol. x, pp. 120–144; and Bull. United States Geol. Survey, 1905, No. 262, pp. 9–31.

the rhombic plates. The readings were made with a microscope having a fixed stage and rotating cross-wires, a $\frac{1}{12}$ inch oil-immersion objective being used. The plates show symmetrical extinction, the cross-wires bisecting the angles in the extinction position. (Fig. 1.)

In order to obtain if possible crystals large enough to give optical interference-figures in convergent light, a lump of the lode-stuff was partially crushed and treated magnetically to extract the ilmenite, biotite, magnetite, &c., which made up the bulk of the specimen. In this way a comparatively small portion of relatively non-magnetic residue was obtained; it consisted largely of rutile, but contained also

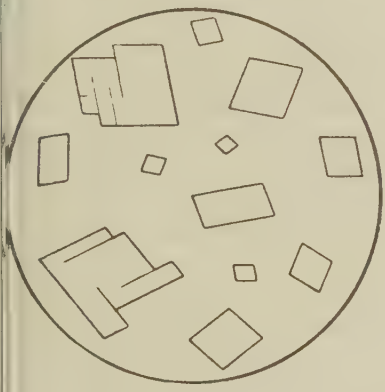


Fig. 1.

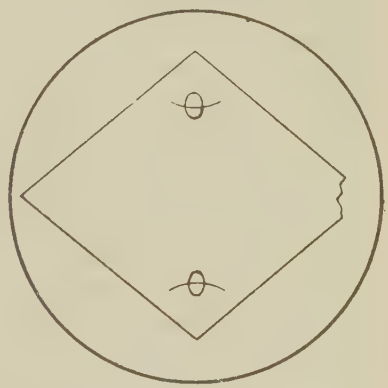


Fig. 2.

Tabular crystals of South Australian carnotite.

Fig. 1.—A portion of the yellow powder from one of the cavities. Magnified 800 diameters.

Fig. 2.—One of the larger crystals obtained by magnetic separation. Magnified 160 diameters.

a number of comparatively large rhombic plates (about 0·25 mm. across); the angles of these had the same average value as those of the smaller plates already described. When examined in convergent polarized light these show very good biaxial figures, the acute bisectrix emerging normal to the surfaces of the plates. The sign of the acute bisectrix, and therefore that of the crystal, is negative. The optic axial plane bisects the obtuse angles; and the value for 2E, as indicated on a graduated eye-piece micrometer, appears to be approximately 90°. The plates show no appreciable pleochroism. Their birefringence effects are to some extent irregular, due to the presence of patches having an isotropic tendency. (Fig. 2.)

c. Conclusions suggested by the chemical and physical characters of South Australian carnotite.—A consideration of the above-mentioned facts concerning the South Australian carnotite leads to the conclusion that carnotite is essentially a definite mineral, as originally inferred by Messrs. C. Friedel and E. Cumenge,[1] and not to any serious extent a mixture of different minerals, as later inferred by Dr. Hillebrand.[2] Such a statement is perhaps rather sweeping, in face of the fact that the chemical evidence in the case of the South Australian carnotite is not very strong, while that adduced by Dr. Hillebrand with regard to the Colorado carnotite is of a high order of exactitude. Indeed it would not be justifiable apart from the fact that, in the Australian occurrence, we have for the first time carnotite which is wholly and definitely crystalline, and which permits of an examination of its physical characters. These physical characters are such as to indicate that carnotite is an orthorhombic mineral, probably with a basal cleavage,[3] and that it belongs to the uranite group of minerals. Its chemical composition indicates that it is essentially a hydrous vanadate of uranium and potassium, as originally shown by Messrs. Friedel and Cumenge; and it may reasonably be regarded as the vanadium analogue of autunite (hydrous phosphate of uranium and calcium), the lime being in part or altogether replaced by alkali. The probability of the existence of a mineral vanadate corresponding to autunite, and the close correspondence in physical characters between autunite and South Australian carnotite, give strong support to this conclusion, notwithstanding the fact that the exact chemical composition of carnotite remains uncertain.

In this connexion it is worthy of note that a variation in the percentage of water, as proved by Dr. Hillebrand, is not peculiar to carnotite, but is also characteristic of autunite. The analyses of the latter mineral quoted by Dana show percentages of water varying from 16 to 22; and Sir A. H. Church[4] has shown that as much as 14 per cent. of this water may be given off in dry air and *in vacuo*. Hence it may be inferred that these minerals are unstable as regards their degree of hydration, and that in them the water plays an uncertain rôle. In the same connexion, it may be noted that both autunite and

[1] C. Friedel and E. Cumenge, Compt. Rend. Acad. Sci. Paris, 1899, vol. cxxviii, p. 532; and Bull. Soc. franç. Min., 1899, vol. xxii, pp. 26 and 26 *bis*.

[2] W. F. Hillebrand, loc. cit.

[3] The birefringence effects at the margin of the splintered plates indicates abrupt stepping due to basal cleavage.

[4] A. H. Church, 'On the composition of autunite.' Journ. Chem. Soc. London, 1875, vol. xxviii, pp. 109–112.

rnotite exhibit irregular birefringence effects, due to the fact that rtain portions tend to become isotropic; and this tendency is not nprobably connected with the instability of these minerals as regards eir state of hydration.

d. Comparison of Australian and Colorado carnotites.—The physical ndition of the Colorado carnotite has been described by Drs. F. L. nsome and G. P. Merrill, in connexion with Dr. Hillebrand's paper.[1] r. Ransome examined it in sections of the sandstone, and found it 'very inutely crystalline, and too indistinct for successful optical study'. r. Merrill examined the carnotite by the fragmental method, and nd that it consisted chiefly of minute dust-like particles, with occa-nal well-defined fragments. Working over a considerable amount of e powder he also observed occasional clusters which he describes as aving the form of flattened radiating crystals with pyramidal termina-ns, which give extinctions always parallel to the axis of elongation. ese are so minute (not over 0·25 mm. in length) and so thin that no ystal could be found so oriented as to give an opportunity of deter-ning its exact character; and it can only be said that the general ape is such as to suggest a hexagonal mineral, though this is by no eans certain'.

Still more recently, the carnotite of Colorado has been described curring as crystals showing hexagonal form, but too minute to give erference-figures.[2]

These descriptions by the American authorities afforded no satis-tory means of comparison between the Colorado and South stralian carnotites. Consequently, a specimen of Colorado carnotite s examined. An examination of a few crumbs of the sandstone ficed to provide crystals similar in habit to those described by . Merrill. Like the Australian crystals, they are tabular in habit, l orthorhombic in symmetry. An isolated crystal plate, measuring more than 0·05 mm. × 0·03 mm., when examined with a $\frac{1}{12}$ inch immersion objective, gave a good biaxial figure. The acute bisectrix s normal to the surface of the plate, the optic axial plane being at ht angles to the long edge or direction of elongation. As far as can determined by an eye-piece micrometer, the optic axial angle appears ave about the same value as that of the Australian carnotite crystals. e optical sign is also negative.

[1] loc. cit., pp. 13 and 21.

[2] H. S. Gale, 'Carnotite in Rio Blanco County, Colorado.' Bull. United es Geol. Survey, 1907, No. 315, pp. 111, 112.

These Colorado crystals were observed in considerable numbers in th small fragments of sandstone examined, being apparently best develope as one would expect, in the interstices of the coarser sandy portion But though they appear to resemble the Australian crystals in the optical characters and in their tabular habit, they differ from them form, as may be seen from the accompanying diagram (fig. 3).

Assuming that the acute angles of the Australian crystals is 78°, a treating the form enclosing them as {110}, the value for the obtu angle enclosed by the form {120} should be about 116°. The observe angle between the prism-edges of the Colorado plates gives an averag reading of 114°. The observed values of angles here given are somewh uncertain, owing to the small size of the crystals; and the limits

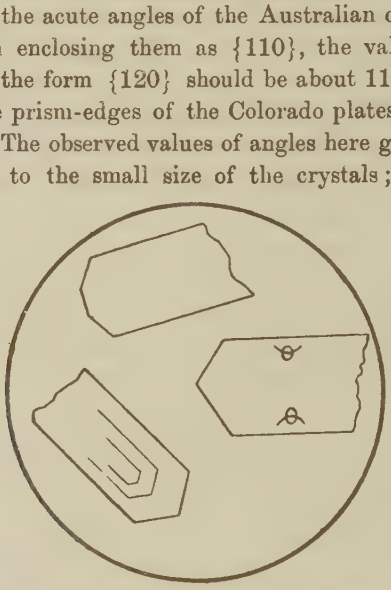


Fig. 3.—Tabular crystals from Colorado carnotite. Magnified 500 diameters

error are probably wide enough to embrace the difference between th values observed. Nevertheless, it is perhaps inadvisable to draw a positive conclusion from this result as to the actual mineralogic identity of these Colorado crystals with those from South Australi Before this can be safely done, it is desirable that larger crystals shou be examined and more uniform readings obtained than those from whi the average values of angles here given have been determined.

But far more numerous than these crystals in the Colorado materi and apparently constituting the greater part of it in some cases, are t irregular crystalline 'granules' referred to by Dr. Merrill. Thou these are for the most part shapeless, some of them take on a rhomb appearance decidedly suggesting the form of the smaller Australi plates. While, therefore, pending the establishment of more exact da it would be hazardous to draw definite conclusions based on a comparis

The Colorado and Australian carnotites, it appears not improbable that they are essentially identical. It should be possible to collect sufficient of the Australian carnotite to get an analysis of the pure orthorhombic crystals. The Colorado material, on the other hand, is very variable in character, even in the same hand-specimen, and it is not at all surprising that the results of analyses should vary considerably, unless the selection of material for analysis is made very carefully and controlled by examination with the microscope. It seems quite probable that a careful selection of material would yield more consistent results than those recorded by Dr. Hillebrand.

(2) Examination of the complex material associated with the Carnotite.

A mineralogical examination of a portion of the massive black constituent which has been already referred to as constituting the bulk of the specimen, indicated that it was made up of an intimate mixture of ilmenite, rutile, and magnetite, with a variable but small amount of other material. A piece of the freshest-looking part of the specimen was selected for analysis. It had a specific gravity 4·33. To the naked eye it appeared homogeneous, though it seemed unlikely from a previous microscopical examination of the crushed material that such could be the case. It was broken into two parts; one of these was crushed and analysed; from the other part a section was cut for examination with the microscope. This section shows that the homogeneous-looking, black material is really heterogeneous and very complex. The slice is made up chiefly of the opaque, black constituent, which is perhaps best described as titaniferous magnetite (ilmenite + magnetite), the ilmenite predominating. This is impregnated with numerous irregular, small patches of material which is translucent and brownish in colour; these consist in part of rutile, but rutile is also present in patches of considerable size.

In addition to the rutile, there is a certain amount of less transparent material lining or filling cracks and cavities, and in some places wrapping round the rutile, from which it can be clearly distinguished. It is optically heterogeneous, but mainly isotropic, and its colour suggests the presence of cerium-bearing decomposition products, but its identity is optically indeterminable. This constituent entirely fills some of the small cavities, and lines others. Some of the cavities which contain it as an outer lining show growing out from it towards the centres of the

cavities, numerous fibrous-looking crystalline growths which are yellow in colour and decidedly pleochroic.

There can be little doubt that this constituent, seen as fibrous growths in section, is carnotite. Its habit of growth in platy aggregates explains its appearance in section, and one is not surprised to find that it shows a decided pleochroism in sections transverse to the plates.[1] The pleochroism is yellow to practically colourless, and may be stated thus :—

$$\mathfrak{c} = \mathfrak{b} \text{ (yellow)} > \mathfrak{a} \text{ (colourless)}.$$

The optical behaviour of these fibrous growths resembles that of the micas in sections normal to the basal cleavage. They compensate across the fibres with a positive quartz-wedge, in accordance with the negative character of the crystals. The birefringence is apparently high, suggesting an approach to that of muscovite.

No constituent identifiable as roscoelite was seen in the section, or indeed in any part of the whole specimen described in this paper.

The portion analysed was found to have the following composition :—

TiO_2	...	51·85 per cent.
Fe_2O_3	...	17·87
FeO	...	17·37
SiO_2	...	1·21
U_3O_8	...	2·25
V_2O_5	...	0·93
Cr_2O_3	...	1·60
CaO	...	0·25
MgO	...	trace
MnO	...	0·24
PbO	...	0·40
ThO_2	...	0·13
Ce_2O_3	...	1·26
La_2O_3 } Di_2O_3 }	...	2·13
Y_2O_3	...	1·15
H_2O	...	1·21
		99·85

This analysis[2] is consistent with the mineralogical description which

[1] The occurrence of the carnotite as platy growths in these cavities accounts for the good crystals obtained by partial crushing and magnetic separation.

[2] In making the above analysis, the estimation of alkalis was inadvertently omitted; an examination of a separate fragment showed that alkalis were present, perhaps to the extent of a few tenths per cent.

as just been given. The titanic oxide is clearly in excess of the amount equired to form ilmenite, the excess being due to the presence of rutile. The uranium and vanadium oxides are present in roughly the same proportions as those of carnotite, though an examination of the slice would ot lead one to expect 3·5 per cent. of this constituent.

The rare earths may be accounted for by the brownish, optically eterogeneous but mainly isotropic constituent, referred to in describing e slice. It may be inferred as highly probable that the rare earths are mbined with titanic oxide and silica. On this assumption, they would present in the form of a mineral consisting essentially of a silicotanate of cerium earths. Apparently the only known mineral which ts in with these requirements is tscheffkinite, all the constituents of hich are present; the cerium, lanthanum, didymium, and thorium xides being in practically the required proportions, whilst yttria is in xcess. The optical characters displayed by the brown translucent conituent seen in the slice are quite consistent with the view that the ineral is tscheffkinite.

Tscheffkinite is a decidedly rare mineral, and there is little or no inforation recorded as to its associates. But, according to Dana, it usually aves a black residue of ilmenite grains when dissolved in nitric acid; nd from this we may infer that it occurs in association and intimately ixed with ilmenite. This fact lends support to the view that the ineral in question is tscheffkinite, a view which seems warrantable on e basis of evidence here presented.

It is perhaps important to state that, as far as one can judge from an xamination of the slice, there appears to be quite enough of the brownish nstituent infilling the cavities, to account for the small percentages of re earths recorded in the analysis. From this and the presence of rnotite, it seems unnecessary to allocate any of the uranium, vanadium, d rare earths to the opaque constituents.

(3) The supposed new minerals of the South Australian carnotite-bearing complex.

The specimens of the supposed new minerals 'davidite' and 'seffomite'[1] now on sale by mineral dealers, appear to be identical with e mineral complex described in this paper. The evidence presented Messrs. Mawson, Rennie, and Cooke in no way conflicts with that

[1] If this is named after Sefström, the discoverer of vanadium, as is presumably case, the supposed new mineral should have been called sefströmite.

here presented. Mr. Mawson's supposed new mineral 'davidite', which he describes as a lustrous black mineral containing over 50 per cent. of titanic oxide, a large amount of iron, together with some uranium, vanadium, and rare earths, may be regarded as ilmenite impregnated with rare-earth titanates, carnotite, and possibly a little rutile.

The South Australian workers have apparently not identified the rutile which forms such an important constituent of the complex. This rutile is black in the mass and brownish when powdered. It has a specific gravity about 4·2. An analysis by Mr. S. J. Johnstone, of the Imperial Institute, shows that it contains about 3 per cent. of iron oxide and about $1\frac{1}{2}$ per cent. of vanadic oxide. It may therefore be described as a vanadiferous nigrine.

There is every reason to believe that the specimen described in this paper was fairly representative of the Radium Hill lode-stuff, as it answered closely to the description given by both the Government Geologist and Mr. Mawson. Its condition indicates that the minerals of the lode-stuff are of a very mixed description. With the possible exception of the carnotite, none of them appears to be free from admixture with the associated minerals. Under such circumstances the existence of new minerals should only be inferred as a last resource to meet difficulties which are otherwise unmanageable. In the present instance, the evidence to be handled undoubtedly presents serious difficulties, but it seems less objectionable to cover this evidence by an appeal to known minerals than by an invention of new ones.

(4) Probable genesis of the Carnotite.

The association of this carnotite-bearing complex with eruptive rocks suggests that the complex owes its condition to the impregnation and metamorphism of a mass of ilmenite during a late phase of eruptive activity. The rutile and magnetite are probably of secondary origin, resulting from the disintegration of original ilmenite. Contemporaneous with this change, and due to the same agencies, new material in the form of uranium, vanadium, and rare-earth compounds was probably added; and it is to this impregnation, directly or indirectly, that the formation of the carnotite is probably to be attributed.

(5) Summary.

1. The radio-active lode-stuff of Radium Hill, near Olary, South Australia, is a mineral complex consisting of an intimate admixture of ilmenite, magnetite, rutile, carnotite, and a mineral which is probably

a titanate or silico-titanate of rare earths, &c., and which may possibly prove to be tscheffkinite or some allied mineral. The predominant constituent is ilmenite, the other minerals being present as impregnations.

2. The carnotite, which occurs sparingly in cracks and cavities, partly as a yellow powder and partly in the form of minute, tabular crystals and platy aggregates, is entirely and definitely crystalline, the crystals belonging to the orthorhombic system. The physical characters, taken in conjunction with the chemical composition, indicate that carnotite is a definite mineral, belonging to the uranite group, and that it may be regarded as the vanadium analogue of autunite.

3. The Colorado carnotite, though not so definite in its crystalline condition as the Australian mineral, contains tabular crystals and platy aggregates which are orthorhombic in symmetry; and it is probable that these are mineralogically identical with those of the Australian carnotite.

4. The supposed new minerals 'davidite' and 'sefströmite' are apparently identical with the complex above referred to.

The authors' thanks are due to Mr. L. J. Spencer, of the British Museum, for generous assistance in a variety of ways during the elaboration of this paper; also to Dr. J. W. Evans for kindly confirming the optical observations.

Postscript by T. Crook (February 14, 1910).—On February 9, 1910, at a meeting of the Geological Society of London, Dr. D. Mawson exhibited specimens of 'davidite' from the Olary lode-stuff. He had seen the proof-sheets of the above paper, and with a knowledge of the results which we had obtained, he stated that 'davidite' is a homogeneous mineral, and that we had not seen it. Two days later Dr. Mawson kindly gave me one of the indistinct, cuboidal crystals of davidite, and I thereby had an opportunity of comparing it with the materials contained in the specimen of lode-stuff which we examined. After having examined an authorized specimen of 'davidite', it seems desirable that this opportunity should be taken to make a brief statement so as to prevent, if possible, any misunderstanding and confusion which might otherwise arise.

Dr. Mawson's 'davidite' is identical with that particular ingredient of our original specimen which we describe as occurring in small patches and having the lustre of ordinary ilmenite (see p. 272). This particular ingredient was not analysed by us, as there was not enough of it; but

Dr. Mawson informs me that full details of chemical analyses by Drs. Rennie and Cooke will be published shortly; and mineralogists will then be in a position to judge more correctly whether 'davidite' is to be regarded as a new and distinct mineral species rather than as an impure ilmenite.

An examination of the genuine 'davidite' has led me to the conclusion that, like the main ingredient of the lode-stuff, it is not homogeneous. The 'davidite' of our specimen occurred in small pieces having an irregular shape, and some of these could be clearly seen to merge insensibly into the main mass of the complex. It is perhaps necessary to remark that the mere uniformity of appearance and continuity of a fracture-surface is not sufficient to prove that the material is homogeneous; and the fragments of the 'davidite' which we examined show unmistakable signs of heterogeneity.

For the present, therefore, and pending the publication of proof to the contrary, one may reasonably continue to regard 'davidite' as a mineral complex which is essentially similar to that which we have described in the above paper.

On the occurrence of the rare mineral Carminite in Cornwall.

By Arthur Russell.

[Read November 17, 1908.]

THE mineral carminite was first described by F. von Sandberger in 1850 in a paper which appeared in Poggendorff's Annalen, entitled 'Carminspath, ein neues Mineral aus der Ordnung der Arseniate'.[1] It occurred near Horhausen, Rhenish Prussia, forming clusters of fine needles of a carmine- to tile-red colour, implanted on quartz, limonite, and chudantite, and accompanied by pyrolusite, clear crystals of mimetite, and an undetermined yellow, earthy mineral. In a subsequent paper in 1858, 'Ueber den Carminspath,'[2] he gave the precise locality as the Louise mine, Horhausen, Rhenish Prussia; and a quantitative analysis, on 0·068 gram by R. Müller, showed the mineral to be an anhydrous arsenate of iron and lead: As_2O_5, 49·11; Fe_2O_3, 30·29; PbO, 24·55 = 103·95. A trace of phosphoric acid was also present.

No other locality appears to have been recorded in mineralogical literature for this rare species; but in the Mineral Collection of the British Museum (Natural History) there are exhibited specimens of carminite from Ems in Nassau. On these specimens the minute needles of carminite are deposited on gersdorffite.

On examining some specimens of scorodite, which I found during 1906 at Hingston Down Consols mine, Calstock, Cornwall,[3] I noticed on one or two of them some tufts of minute, red needles of an unknown mineral. The very small quantity of the substance precluded, however, the

[1] F. von Sandberger, Ann. Phys. Chem. (Poggendorff), 1850, vol. lxxx, pp. 391–392.

[2] F. von Sandberger, ibid., 1858, vol. ciii, pp. 346 347.

[3] Hingston Down Consols mine commenced working about 1846, and was for many years a large producer of copper ores. After being abandoned for a long time, it was re-opened about 1904 by the Clitters United Mines Co. Ltd., since which date it has produced considerable quantities of tin, copper, wolframite, and arsenical pyrites, and also some fluor-spar. Thanks to the courtesy of the late manager, Captain J. Paull (now of South Crofty mine), Mr. Richards and myself were able to visit the mine on many occasions and collect the material described in this paper.

possibility of my determining the species. A sharp look-out was therefore kept in the hope of finding more material, and in the early part of 1908 my friend Mr. Jehu Richards, of Callington, a keen mineral-collector, was successful in obtaining from the same locality several excellent specimens of the mineral, all of which he kindly sent to me. Since then, although both Mr. Richards and myself have repeatedly visited the mine, no more specimens have come to light. The exact spot at which the mineral occurred was the 65 fathom level on the south lode, in granite.

The carminite occurs as tufts of minute carmine-red or reddish-brown needles, the colour being very beautiful and characteristic. These tufts are either disposed on beautiful bluish crystals of scorodite, or on quartz crystals, or poised as delicate star-like aggregates on brilliant, colourless hexagonal prisms of mimetite. On other specimens the carminite occurs as a fine velvety coating on chalcopyrite and blende, and rarely in the form of minute stalactites with a drusy surface. In one case the mineral forms brilliant carmine-red, crystalline aggregates, studded over hollow spindle-shaped crystals of mimetite.

Viewed under the microscope with a high power, the needles are seen to taper to a fine point. They are strongly refractive (greater than methylene iodide, 1·74), show strong double refraction, give straight extinction, and are optically positive. No optic axial figure was observable through them in convergent light. Dr. G. F. Herbert Smith very kindly examined some of the needles with a view to measurement but he was unable to get any definite reflections. I am indebted to him also for the identification of the forms on the associated mimetite.

The needles scratch calcite with difficulty, the hardness being therefore slightly over 3. The specific gravity could not be determined, owing to lack of pure material. Before the blowpipe, the mineral is easily fusible to a steel-grey globule, and with soda yields beads of lead. Heated in a bulb-tube with charcoal, it gives a mirror of arsenic. It is difficultly soluble in hot, dilute hydrochloric acid; the solution reacts for ferric iron, and, on cooling, deposits needles of lead chloride.

Since the amount of material used by Müller for his analysis was exceedingly small (0·068 gram), his results were probably not very accurate. It is therefore to be regretted that in the case of the Cornish mineral it has been found impossible to make a quantitative analysis partly owing to lack of material, and partly owing to the difficulty of separating the carminite from the other closely associated minerals.

The following are the associated minerals:—massive mispickel chalcopyrite; blende of a steel-blue colour; earthy covellite; scorodite

rth in brilliant crystals (the finest ever found in Cornwall) and in light eyish-blue, cellular and stalactitic masses; pharmacosiderite[1] in small, light green cubes; mimetite in slender, colourless crystals with the rms c {0001}, m {10$\bar{1}$0}, a {11$\bar{2}$0}, x {10$\bar{1}$1}, and also in stout, eam-coloured prisms and tapering forms; anglesite, rarely in colourless, riated crystals, imperfectly developed; opaque, white quartz crystals; d colourless, pale violet, or greenish, etched fluor-spar.

Cornwall has long been famous for the number of rare minerals it has duced, and it is therefore gratifying that we should still be able to add m time to time the names of species new to the county, and in this e new also to the British Isles.

[1] The beudantite occurring with carminite at the Luise mine, Horhausen, as at first mistaken by Sandberger for pharmacosiderite, but later (Ann. ays. Chem. (Poggendorff), 1857, vol. c, p. 612) he showed its true nature. The rnish mineral was examined by the writer, and is undoubtedly pharmaco-lerite.

On the occurrence of Gyrolite in County Antrim.

By F. N. A. Fleischmann, M.A., F.C.S.

[Read June 15, 1909.]

ALTHOUGH the mineral gyrolite has long been known to occur in the British Isles, namely in the basalt lavas of Skye, Mull, and the Treshnish Islands, &c., off the west coast of Scotland, and has more recently been described from the cliffs between Ardtornish Bay and the fault of Dearg Allt in Argyllshire on the mainland,[1] no instance of its occurrence in the lavas of the north of Ireland has hitherto been recorded.

The examination, however, of a large number of specimens collected both for me and by myself during the past year and a half has shown that the mineral, though occurring in small quantity relative to the other zeolites with which it is associated, is fairly widely distributed throughout the harder lavas in the neighbourhood of Belfast.

Up to the present time I have identified the mineral on specimens obtained from the following localities :—

Two quarries in the townland of Legoniel, which are situated one on the north and the other on the south side of the small eminence (locally called Cat Carn) on the high ground between Wolf Hill and Squires Hill; a quarry in the townland of Collinward, above the village of Whitewell on the slopes of Collinward; three quarries in the townland of Ballyhenry to the north-west of Carnmoney Hill; and two quarries on Carnmoney Hill, the one on the north-east slopes in the townland of Ballyduff, the other on the south-west slopes in that of Carnmoney.

These quarries are worked on short contracts for road-metal as it is wanted in the neighbourhood, and, unless a considerable amount of work is being done, specimens are not easy to obtain, even though they may be actually plentiful.

Quarries on Cat Carn, townland of Legoniel.

The first locality in which I noticed the mineral was the quarry on the northern slopes of this hill. In it but one flow is exposed at present, consisting of a fine-grained olivine-basalt containing magnetite in fair

[1] J. Currie, Mineralogical Magazine, 1905, vol. xiv, p. 93.

quantity. The olivines are small and often surround segregation-patches of minutely ophitic augite and felspar-laths, the latter giving the sections a mottled appearance. It shows considerable chloritization and oxidation, and also some serpentinization.

Cavities are numerous and reach at times six inches or more across. The gyrolite occurs in small hemispherical and spherical aggregates, rarely exceeding $\frac{1}{3}$–$\frac{1}{4}$ of an inch in diameter, which when broken open are found to consist of pearly leaflets. The latter are uniaxial and negative, and have strongish double refraction. Their specific gravity is 2·35–2·40.

In the usual type of occurrence the gyrolite nodules are scattered here and there, but sometimes they are grouped into a crust on the coating of faroelite that almost always lines the cavities, and are associated with brilliant, colourless, cube-like, and cubo-octahedral apophyllite crystals. In addition to the faroelite, gyrolite, and apophyllite, a secondary growth of thomsonite, similar in appearance to the so-called 'sphaerostilbite' from the Faroe Islands, and small, yellowish calcite crystals are by no means infrequently present, and more rarely analcite. Very rarely cavities are found in which the gyrolite is deposited on chabazite.

No very definite order of deposition can be observed, beyond the fact that in the common type of occurrence faroelite is the first mineral deposited. On the whole, the gyrolite is anterior to the secondary thomsonite, while as regards the apophyllite it occurs deposited both before and after the latter mineral.

Pure material was difficult to obtain, as in most cases minute crystals of one or other of the associated minerals cover the surfaces of the nodules. For examination as much pure mineral as possible was picked by hand, and this was supplemented by material that was obviously contaminated only with calcite, from which it was freed by treatment with cold citric acid solution. The aggregates were broken up for this purpose, but not powdered, then treated with the acid, washed, and air-dried.

As the external aspect of the nodules varied considerably, even when uncontaminated, several samples were prepared and the water-content of each determined by Penfield's method. No appreciable difference in the percentage of water was, however, observed. This was done in view of the recent work of F. Cornu on the 'micaceous zeolite' group[1] in

[1] F. Cornu, Min.-Petr. Mitt. (Tschermak), 1907, vol. xxv, pp. 513–521. F. Cornu and A. Himmelbauer, 'Untersuchungen am Apophyllit und den

which he showed that, in addition to the two known members of the group, gyrolite and zeophyllite, there exists a third, reyerite, [and probably a fourth] which is externally indistinguishable from those previously known, and which differs but slightly in physical characteristics, but which contains far less water.

The author is at present engaged upon a complete analysis of the minerals. The results [$SiO_2 = 51{\cdot}69$, $CaO = 30{\cdot}44$, $Al_2O_3 = 3{\cdot}64$ per cent.] obtained so far, in addition to the determination of the water, agree well with the analyses of the mineral from other sources. The determination of the percentage of water gave $H_2O = 13{\cdot}44$.[1]

The mode of occurrence of the mineral in the quarry on the south side of the hill is practically identical with that already mentioned, both as regards the habit of the mineral and its associates. The rock also is similar but rather more chloritized and oxidized, and the mottled appearance is more strongly marked.

Quarry on Collinward, in the townland of Collinward.

Here, as in many other Antrim basalt quarries, two distinct layers are visible. At the entrance to the quarry, which is situated on a steep hill-side, is a small exposure of decomposed, highly vesicular basalt, containing in its cavities chiefly analcite and more rarely chabazite, while the main exposure on the quarry face is composed of hard, coarse-grained olivine-basalt. This rock is extremely rich in olivine, which occurs in large porphyritic crystals in a ground-mass of felspar-laths and ophitic augite. Magnetite is fairly frequent, especially included in the olivines, which are often much oxidized.

The cavities, which are usually large and very irregular in form [the largest noted so far being three feet long by eight inches across at the widest part], are found at intervals in patches. They contain: gyrolite as irregular groups and tufts of small, very brilliant, thin, pearly leaflets; large tabular crystals of apophyllite; large hemispheres composed of radiating crystals up to one and a half inches in diameter, which from their optical properties and a partial analysis are mainly composed of thomsonite, but which often carry fine radiating needles of mesolite on their surfaces [these are almost isotropic and show only

Mineralien der Glimmerzeolithgruppe.' I. 'Untersuchungen am Gyrolith,' von F. Cornu. Sitzungsber. Akad. Wiss. Wien, Math.-naturw. Kl., 1907, vol. cxvi, Abt. i, pp. 1213–1241.

[1] F. Cornu, loc. cit., gyrolite from Böhmisch-Leipa, $H_2O = 13{\cdot}06$ %; gyrolite from Skye, $H_2O = 12{\cdot}80$ %; reyerite from Greenland, $H_2O = 6{\cdot}73$ %.

faint bluish tinge between crossed nicols]; hemispherical aggregates nd crusts of thomsonite formed of more or less interlacing crystals; arge, colourless analcite crystals; compact and powdery saponite; and nore rarely chabazite and calcite.

The gyrolite, which occurs on nearly every specimen but generally nly in small quantity, is found in every possible position relative to the ssociated minerals, dating from the earliest to the latest period of eposition.

A determination of the percentage of water in the mineral gave $H_2O = 13{\cdot}06$.

Quarries in the townland of Ballyhenry.

Of the group of the three quarries in this townland, two are situated 00 yards apart, close by the road which runs north-west from Glengormy o Ballyclaire Junction, and the third a short distance south-west of the nore southerly of the first two.

In the most northerly quarry, which is known as Nelson's quarry, wo basalt flows are exposed. The upper one consists of hard, somewhat phitic olivine-basalt, which is full of very small, chiefly granular nd often considerably oxidized olivines, and contains also good mag- etite crystals. Most of the augite also is granular, but some is ophitic. he lower flow is composed of soft, decomposed, highly vesicular basalt, ne cavities of which contain small chabazite crystals and sometimes small nalcites and faroelite nodules.

The gyrolite occurs in the upper flow in aggregates similar to those rom Cat Carn. They are, however, more commonly packed together in rusts and their leafy structure is much more distinctly marked on their rfaces. They are associated with cube-like apophyllite crystals, condary thomsonite (which is often very compact), and faroelite. The st is, as a rule, present only in very small quantity, generally as an most microscopic crust next the cavity-walls.

A determination of the amount of water in the mineral gave $H_2O = 13{\cdot}30$ per cent.

In the quarry south-east of the last, two flows are again visible. The pper one consists of hard, fine-grained, ophitic olivine-basalt, the sections which are very strongly mottled in appearance owing to the presence numerous, very minutely ophitic patches surrounded by rather coarser aterial. It generally shows considerable chloritization and oxidation. he lower flow consists of much altered, highly vesicular basalt yielding

chiefly chabazite, but also in places, where the rock is deep red in colour, stilbite. This flow is exposed in a few places only on the floor of the quarry and opposite the main rock-face. Cavities are fairly numerous in parts of the upper flow, but they are mostly small and solidly plugged.

The gyrolite varies considerably in habit, ranging from compact, hemispherical aggregates like those from Cat Carn to loose aggregates of pearly leaflets like those from Collinward. It is associated with faroelite nodules (which are sometimes of remarkable size and generally well isolated from each other), cube-like apophyllite, fine hairs of almost isotropic mesolite, and small calcite crystals.

In the third quarry only the top flow is exposed, and this is similar in every way to the last. At present I have obtained but two examples of the mineral from this quarry. On these it occurs in loosely aggregated leaflets on faroelite, with thick-tabular and cube-like apophyllite crystals.

In general, these three occurrences differ from those on Cat Carn in the relative scarcity of apophyllite, which at that locality is, with the exception of faroelite, the commonest mineral.

Quarry on Carnmoney Hill, townland of Ballyduff.

In this quarry, which is the middle one of a group of three situated on the hill-side between 500 and 600 feet above sea-level and which has only recently been re-opened, there is only one flow visible. The rock is an olivine-basalt characterized by the presence of good porphyritic olivine crystals in a very fine-grained ground-mass of felspar-laths and granular augite.

Cavities are very scarce; of those found so far, only one contained gyrolite. In this instance the cavity was filled with radiating, leafy aggregates of the mineral in association with greenish saponite.

Quarry on Carnmoney Hill, townland of Carnmoney.

Two distinct layers are here visible; the upper one consisting of highly vesicular, decomposed basalt, yielding occasionally faroelite and small analcite crystals; the lower of hard olivine-basalt, similar in character to that in the townland of Ballyduff. This rock is rudely columnar over part of the exposure.

Cavities are not numerous, and are generally poor. Faroelite is the mineral most commonly found. In a few instances, however, aggregates

of gyrolite (similar to those from Cat Carn), in association with cube-like and cubo-octahedral apophyllite crystals, are deposited on the faroelite.

The author, who is at present engaged upon a systematic examination of the minerals from the various localities mentioned, desires to express his thanks to Dr. G. T. Prior and Mr. L. J. Spencer for their kind assistance, and to Mr. F. H. Butler, who undertook the examination of the rock-sections.

On the species Pilolite, and the examination of a specimen from China.

By G. Stafford Whitby, A.R.C.S., B.Sc.

Analytical Laboratories, Royal College of Science, London.

[Communicated by the Editor, and read June 15, 1909.]

A SAMPLE of supposed 'vegetable asbestos' obtained in the west of the province of Süchwan, China, was forwarded in 1907 by Mr. J. H. Bristow,[1] the British Consul at Chungking. It was later[2] reported by Mr. H. Phillips, the British Consul at Chungking, that the so-called 'vegetable' asbestos previously mentioned 'is found in crevices between rocks in the districts of Lei Po T'ing and P'ing Shang Hsien, in the prefecture of Sui-fu.' The author has recently been informed that it occurs along the length of the Yangtse-kiang generally, from Sui-fu to the Huili-chou neighbourhood—i.e., along the Süchwan-Yunnan border on the outskirts of the Man Tzu country. According to the quaint idea of the local Chinese, this so-called 'vegetable' asbestos (Ti Chien P'i) is formed by the action of certain gases on the secretion of a worm.

This is the material the results of an examination of which are here recorded, and which proves to be neither 'vegetable' nor 'asbestos', but a very interesting specimen of pilolite. It has the appearance of a mountain-leather of particularly fine quality. It consists of thin, flexible sheets, soft and felt-like, which remind one of glove kid; and, when rubbed against itself, it emits a squeaking noise, similar to that obtained when two pieces of leather rub over one another. It is white in colour, but is crossed by very light brown lines, which are parallel and about one-eighth of an inch apart. It is the finest specimen of mountain-leather that the author has seen. There is a sample of it in the Mineral Collection of the British Museum (Natural History).

Under the microscope it is seen to consist of fine, interlaced fibres. The felted structure of the mineral is very obvious during the process of

[1] Board of Trade Journal, October 24, 1907, vol. lix, p. 183.
[2] Op. cit., December 24, 1908, vol. lxiii, p. 620.

grinding; the pestle has to be urged backwards and forwards in order to pull the fibres apart. The fibres have a refractive index of about 1·5, and, with polarized light, give straight extinction.

At 100° C. a considerable amount of water is lost, but no change in appearance occurs; and, further, on allowing the mineral, which had been dried at 100° C., to stand in the atmosphere for several days, it re-absorbed exactly the same amount of moisture as that which had previously been expelled. At a higher temperature, more water was lost, the whole of it being driven off at the temperature of the Bunsen-burner. The mineral does not give up its water in a vacuum-desiccator. A powdered specimen had undergone no change in weight after a week *in vacuo*. The contraction undergone on heating is very great. When a whole (i.e. unpowdered) piece is heated in a platinum crucible over a Bunsen-flame, no contraction takes place, but when this piece is held directly in the Bunsen-flame, it shrinks at once. (No change in weight accompanies this contraction.) That the very characteristic contraction which the mineral undergoes on heating is due to partial fusion effected by the higher temperature, is shown by the fact that, when heated in the oxyhydrogen flame, it easily melts. When the material contracts, or even when it is heated only sufficiently to expel the water, it becomes brittle. This fact bears on its proposed commercial applications. An experimental shipment was made some time ago, and it was suggested that, since the material was stated to be 'incombustible and bullet-proof,' it might be employed in some naval or military direction. Another suggestion was that it might be used in the preparation of incandescent mantles. The fact that it contracts greatly and becomes brittle when heated makes it difficult to conceive how it could be applied in such ways.

The following results were obtained on analysis (using 0·6221 gram of material):—

	Per cent.	Molecular ratios.		
(Water lost at 100° C.	6·06)			
Total water (lost on ignition) ...	18·12 ...	1·0067	or	6·94
Silica	54·94 ...	0·9111	...	6·28
Alumina	14·83 ...	0·1451	...	1·00
Ferrous oxide	0·55 ...	0·0076	0·2789	1·92
Magnesia	10·94 ...	0·2713		
	99·38			

A trace of manganese is also present. These numbers were confirmed by

the analysis of another but smaller quantity. The formula most nearly corresponding to the above figures is—

$$6SiO_2 . Al_2O_3 . 2MgO . 7H_2O,$$
$$\text{i.e., } Al_2O_3 . 2SiO_2 + 2(MgO . 2SiO_2) + 7H_2O.$$

This formula requires—

	Per cent.
Silica	53·95
Alumina	15·24
Magnesia	12·02
Water	18·79
	100·00

The large amount of water present shows the mineral not to be a true amphibole-asbestos. Thus it cannot be regarded as a mountain-leather in the narrower sense of that term, as applied to leather-like forms of asbestos. Further, the amount of magnesia present is too small to allow of the mineral being regarded as a serpentinous asbestos. Of asbestiform minerals, it conforms most nearly to pilolite.

Pilolite was described as an independent species in 1879 by Heddle,[1] who applied the term to certain felted asbestiform minerals found in Scotland, which could not be identified with asbestiform hornblende or serpentine. The mean of Heddle's seven analyses (three of 'mountain-leather' and four of 'mountain-cork') is: SiO_2, 51·64; Al_2O_3, 8·62; Fe_2O_3, 0·78; FeO, 2·88; MnO, 1·41; CaO, 0·98; MgO, 10·21; H_2O, 23·27; and the nearest corresponding formula is $10SiO_2 . Al_2O_3 . 4MgO . 15H_2O$, i.e., $Al_2O_3 . 2SiO_2 + 4(MgO . 2SiO_2) + 15H_2O$.

G. Friedel[2] in 1901 described a silicate which he then regarded as a new species, and to which he gave the name lassallite, but which he later[3] recognized as being sufficiently accurately described for the present as belonging to Heddle's species pilolite. Friedel's specimens were from Miramont in Auvergne, and gave analytical data the simplest corresponding formula to which is $12SiO_2 . 2Al_2O_3 . 3MgO . 8H_2O$. The mean of Friedel's analyses of a specimen from the Pyrenees is SiO_2, 52·1; Al_2O_3, 16·83; MgO, 7·5; CaO, 0·71; FeO, 1·32; H_2O, 20·85; and the simplest corresponding formula may be taken as

$$5SiO_2 . Al_2O_3 . MgO . 3\tfrac{1}{2}H_2O,$$

[1] M. F. Heddle, Mineralogical Magazine, 1879, vol. ii. p. 206.
[2] G. Friedel, Bull. Soc. franç. Min., 1901, vol. xxiv, p. 6.
[3] G. Friedel, op. cit., 1907, vol. xxx, p. 80.

ut these figures are not so valuable, owing to the presence of grains of uartz in the mineral.

The material described in this paper is from quite a new source, hina, and is seen to differ in some respects from the specimens from cotland and France. It contains no calcium, and only a trace manganese. It contains rather more silica than the specimens om the other localities; the water-content is somewhat different; hilst the amounts present of alumina and magnesia differ distinctly om those in the other samples, which themselves do not agree with one nother. Again, the formulae corresponding to the analytical data und for the specimens of pilolite obtained from the three different arts of the globe mentioned are not the same. Heddle represents ilolite as a combination of one molecule of aluminium silicate with ur molecules of magnesium silicate and fifteen molecules of water ($Al_2Si_2O_7 \cdot 4MgSi_2O_5 \cdot 15H_2O$); Friedel's formulae do not correspond to ny definite combination of simple silicates; whilst the formula arrived t in this communication represents pilolite as a combination of one olecule of aluminium silicate with two molecules of magnesium silicate nd seven molecules of water,

$$Al_2Si_2O_7 \cdot 2MgSi_2O_5 \cdot 7H_2O.$$

It will thus be seen that the species pilolite is not yet as precisely efined as one could wish, and, for the present, the term must be given ich an extension as is implied in its application to those varieties of ountain-leather and mountain-cork which—

(1) cannot be identified with asbestos on account of the presence of large amount of water and the absence of any considerable amount lime;

(2) cannot be referred to serpentinous asbestos on account of the latively small amount of magnesia which they contain; and

(3) hold their water in such a way that, when it has been expelled by ating, it is gradually re-absorbed from the atmosphere exactly in such mount as to make the water-content what it was originally.

Such a definition of the species seems to allow considerable latitude, ut it takes account of all the differences, applies to all the pilolites itherto described, and must be regarded as marking out the species in hat, for the present, is a satisfactory manner. Further, it may be ointed out that the pilolite described in this paper probably represents typical and particularly pure variety, on account of (1) its clean ppearance; (2) the absence of lime and manganese, and the lowness the iron-content; and (3) the simplicity of its chemical formula. The

analytical figures lead one to presume that the type of the mineral is a combination of aluminium silicate and magnesium silicate with water, and it is to be observed that the Chinese specimen conforms to this type very closely—much more than do the Scotch or French samples. There is merely a replacement of a little of the magnesia by ferrous oxide; whilst in the original specimens of Heddle there is, in addition, a replacement of some of the magnesia by lime and by manganese oxide, and of some of the alumina by ferric oxide; and in the specimens of Friedel, a replacement of some of the magnesia by ferrous oxide and by lime.

For Mr. Spencer's kind help in connexion with this paper the author wishes to express his gratitude.

On an occurrence of native Copper with tin-ore in the Federated Malay States.

By J. B. Scrivenor, M.A., F.G.S.

Geologist to the F.M.S. Government and formerly of H.M. Geological Survey of the United Kingdom.

[Read November 16, 1909.]

EARLY in 1909 a small quantity of fine sand was brought to the writer from a big Chinese-owned mine at Rotan Dahan, in the District of Kinta, the leading tin-producing district of Perak and, indeed, of any of the Federated States. The sand was a concentrate, and had been obtained in the final washing of the rough tin-ore concentrates, whereby the heavier impurities, generally referred to locally as 'amang', are separated from the cassiterite. In this case, however, the Chinese miner found that there was a reddish mineral present which he could not separate from the cassiterite. This proved to be native copper, and the mode of occurrence is of sufficient interest to warrant a brief description of this and other samples of ore from the same mine and an adjoining mine working on the same deposit.

The tin-ore is being won from a mass of partially decomposed, soft schists *in situ*, overlying limestone. The working face is about 80 feet high, and small patches of iron-pyrites in minute crystals are of frequent occurrence in the clayey mass. The clay is cut by hand and puddled, a sand rich in cassiterite being obtained as a result. This is concentrated into a marketable product in native-made sluice-boxes, or 'lanchuts,' and by a final washing by skilled workmen in fine-meshed sieves. The undersized material that falls through the sieves is generally washed again, and a low-assay, fine tin-ore obtained from it. It was in this undersize that the native copper was first found.

The whole of the sample submitted to the writer passed through a wire sieve of ninety meshes to the inch, with the exception of a few pieces of cassiterite. On treating portions of the sand with nitric acid, 72 per cent. dissolved with the separation of a very little sulphur. The remaining 28 per cent. assayed 71·5 per cent. tin, and was found to consist of cassiterite with some zircon. Microscopic examination of the

original sand also showed that the soluble portion consisted of native copper and a trace of iron-pyrites. No chalcopyrite was detected. But the most remarkable point about the concentrate was that the copper occurred for the most part in beautifully sharp crystals, varying considerably in form, and sometimes twinned. Roughly spherical masses occur too, but the minute crystals predominate, as can be seen when the material is mounted on microscopic-slides.[1]

Later in the year the writer heard that the same miner had been unable to sell two parcels of ore owing to the amount of copper in them. Samples of these were obtained, one being coarse, medium, and fine ore mixed, the other medium and fine ore only.

On grading the first sample it was found that the oversize in a $\frac{1}{30}$ inch mesh sieve contained only a trace of copper, but that the amount increased greatly with the fineness of the grade. Iron-pyrites also was abundant in the finer grades, but negligible in the $\frac{1}{30}$ inch mesh oversize.

Grading the second sample showed that such treatment was incapable of freeing any portion of the ore from copper. All the grades contained a high percentage of copper and of iron-pyrites.

In both the above cases the copper is present as shapeless grains, partially oxidized on the surface. No crystals were found, nor was chalcopyrite detected with certainty. Arsenopyrite, however, and some zircon were found.

Another concentrate containing native copper was obtained from the adjoining mine. The oversize of a $\frac{1}{30}$ inch mesh sieve contains arborescent growths of copper crystals, while the lower grades contain shapeless and considerably oxidized grains. Fresh and oxidized iron-pyrites is abundant, and some small, dull black, non-magnetic crystals were seen that could not be identified, but that might be oxidized crystals of copper. The remainder of the concentrate consisted of cassiterite, with occasional grains of zircon, tourmaline, and monazite.

On the whole of the working faces of these two mines the writer has not detected any trace of copper salts, but the extraordinary sharpness of the crystals in the first concentrate shows that they are very probably the result of reduction *in situ* of a copper salt held in solution by water

[1] Three of these slides have been presented to the Mineral Collection of the British Museum (Natural History). They were prepared after the concentrate had been in the writer's possession for some time, and the sand was treated with weak hydrochloric acid to remove the tarnish. When the concentrate was fresh, the crystals of copper showed brilliant metallic surfaces.

percolating through the schists from above, which also probably brought down the zircon crystals, found with the cassiterite, from alluvial deposits.

It is hoped that sufficient material will be found available to render practicable the removal of the copper by an oil-flotation process or by acids, thereby obtaining two marketable products. At present an interesting mineral occurrence of a valuable metal seriously threatens the prospects of two mines.

On the occurrence of Alstonite and Ullmannite (a species new to Britain) in a Barytes-Witherite vein at the New Brancepeth Colliery near Durham.

By L. J. Spencer, M.A., F.G.S.

Assistant in the Mineral Department of the British Museum.

[Read November 16, 1909.]

THE mining village of New Brancepeth,[1] in the parish of Brandon and Byshottles, is situated in the Durham coalfield at a distance of four miles to the west of the city of Durham. One of the faults which intersect the sandstones, shales, and coal-seams (the Harvey, Busty, and Brockwell seams) of the Coal Measures at this place has, at its eastern end, an east to west direction with a downthrow of 120 feet and a hade of 20° to the south. Along this portion of its course the fault is of the nature of a fissure-vein, with a width varying from a few inches to 16 feet. The material filling the vein consists mainly of barytes. In places, especially where the walls of the vein are of sandstone, the pure white, massive barytes extends throughout from one sharply-defined cheek to the other. Usually, however, the material filling the vein is much brecciated, and fragments of sandstone, coal, and clay are intermixed with the barytes. The barytes is mainly confined to the fissure, but for a distance of a few yards from the vein the beds of sandstone and coal are impregnated with barytes and show it along their joint-planes. The witherite forms irregular patches in the barytes, but at greater depths it forms more or less well-defined selvages on either side of the vein, with the barytes in the centre. The minerals in the vein are, for the most part, massive, but some crystal-lined cavities are found, both in the massive barytes and in the brecciated portions with fragments of sandstone and coal. Metallic minerals are present in very insignificant amount as small strings and pockets.

This barytes vein was discovered in the New Brancepeth Colliery about fifteen years ago, and during the last five years it has yielded

[1] The New Brancepeth Colliery is also known locally as the Sleetburn Colliery, being near to an old farm-house of that name.

about 30,000 tons[1] of barytes. A description of it was given by Mr. Robert Peel[2] in 1900; but curiously, although finely crystallized minerals have been found, the occurrence has remained unknown to mineralogists.[3] In this place I desire to express my thanks to the colliery proprietors, Messrs. Cochrane & Co., Ltd., and in particular to Mr. Brodie Cochrane, one of the directors, who kindly gave me every facility for examining the minerals, and who also presented several fine specimens for the British Museum collection; to the manager, Mr. Robert Peel, for much valuable information and specimens courteously given; and to the underground manager, Mr. Andrew Kerr, for conducting me underground to see the minerals *in situ*.

The finding of the rare minerals alstonite and ullmannite in a coal mine is somewhat unexpected. But the type of vein in which they occur does not appear to differ from those abundantly present at lower horizons of the Carboniferous system in the adjacent portions of the counties of Durham, Northumberland, and Cumberland; the principal difference being that the vein is here met with in the Coal Measures instead of in the Carboniferous Limestone series. This difference is, however, more apparent than real, for in this region the Carboniferous Limestone series consists largely of beds of sandstone and shale with some workable seams of coal. Thirty miles north-west of Durham, at the Fallowfield mine and the Settlingstones mine, near Hexham in Northumberland, there are large veins of barytes and witherite in the Carboniferous Limestone series; and in the Fallowfield mine there is a 5-feet seam of coal. Here also (at Fallowfield) the witherite is not infrequently intimately associated with coal, galena, and alstonite. At the only other locality known for the species alstonite, namely, the Brownley Hill mine, near Alston in Cumberland, there are also seams of coal (here, however, quite thin) with the sandstones, shales, and limestones of the Carboniferous Limestone series.

[1] According to the official (Home Office) statistics, the amount was 10,297 tons in 1907, and 5217 tons in 1908.

[2] R. Peel, 'Notes upon an occurrence of barytes in a twenty-fathom fault, at New Brancepeth Colliery.' The Colliery Manager and Journal of Mining Engineering (The Organ of the National Association of Colliery Managers), London, 1900, vol. xvi, pp. 56–58.

[3] In 1907 I selected from the stock of a dealer in the north of England some small specimens of crystallized barytes with witherite, which were labelled 'Rookhope, Weardale, Co. Durham'. Having previously visited Rookhope, I had reason to question this statement of locality, and on making inquiries I learnt that the specimens had come through a miner living at Rookhope, from whom I obtained news of the New Brancepeth occurrence.

A deposit of barytes in a fault at the Lumley Colliery, four miles north of Durham, has been compared by Prof. G. A. Lebour[1] with the New Brancepeth vein; and Prof. H. Louis[2] has described a fault-vein (containing galena, calcite, and iron-pyrites) in the Wearmouth Colliery. A large body of barytes has also been found in the Felling Colliery, near Newcastle-on-Tyne.[3] It is clear that these mineral-veins in the Lower Coal Measures are simply the upward continuations of veins (here also usually fault-veins) which intersect the rocks of the Carboniferous Limestone series lying beneath.

In this connexion it may be remembered that barium has on several occasions been detected in the mine-waters of the Durham and Newcastle districts, and that these waters deposit barium sulphate in the pipes through which they are conveyed from the pits.[4] Mention may also be here made of the occurrence of barium sulphate as a cementing material in sandstones of later date than the Coal Measures, namely those of the Trias, as recorded from several places in the Midlands of England by Prof. F. Clowes[5] and others.

In the New Brancepeth vein I have detected the following nine mineral species:—

Alstonite.

(Barium and calcium carbonate, $[Ba,Ca]CO_3$.)

This species has hitherto been recorded from only two localities, namely the Brownley Hill mine[6] in the parish of Nenthead, near Alston

[1] G. A. Lebour in the discussion of R. Peel's paper, loc. cit., p. 58.

[2] H. Louis, 'Note on a mineral vein in the Wearmouth Colliery.' Trans. Inst. Mining Engineers, 1903 (Session 1901–2), vol. xxii, pp. 127–129.

[3] R. C. Clapham and J. Daglish, 'On minerals and salts found in coal pits.' Trans. North of England Inst. Mining Engineers, 1864, vol. xiii, pp. 219–226.

[4] F. Clowes, 'Deposits of barium sulphate from mine-water.' Proc. Roy. Soc. London, 1889, vol. xliv, pp. 368–369.

[5] F. Clowes, Proc. Roy. Soc. London, 1889, vol. xliv, p. 363; 1899, vol. lxiv, p. 374.

[6] This locality is incorrectly given in all the textbooks as 'Bromley Hill', having been given as such in the papers of J. F. W. Johnston and T. Thomson in 1835–7, though in one place (Thomson's description of 'sulphato-carbonate of barytes') it appears correctly as Brownley Hill mine. There is no hill of this name, and it is simply the name of the mine. On the six-inch ordnance map it appears as 'Brownleyhill Dressing floor'. Mr. Jacob Walton, of Alston, writes to me (August, 1909) respecting the history of alstonite: 'This mineral was first obtained at Brownley Hill mine about 1835 [i. e. 1834], when my grandfather, Jacob Walton, was manager. As far as I can recollect, it was found in a small vein or branch leading from a larger vein, called the Jug vein, and

in Cumberland, and the Fallowfield mine in the parish of St. John Lee, near Hexham in Northumberland, at both of which it appears to have been first noticed in the year 1834. These mines were formerly worked for lead (galena), but at the present time the Brownley Hill mine is being worked for zinc (zinc-blende). At both places the alstonite is deposited on either calcite or witherite.

In the New Brancepeth vein, alstonite is associated with corroded barytes and lenticular crystals of witherite in a sandstone breccia with fragments of coal. It seems to be of quite local distribution: I have seen only five specimens, and none down the mine. It occurs as thin platy aggregates of crystals around the barytes, or as groups of crystals scattered over the surface of the witherite. The order of succession is (1) barytes, (2) witherite, and (3) alstonite. The mineral no doubt owes its origin to the action on the barytes of carbonated waters containing calcium in solution, at a period subsequent to the formation of the witherite. Alstonite is the only mineral[1] containing calcium which occurs in the vein, and its local distribution suggests that perhaps there was only one small feeder of water carrying calcium into the vein.

The crystals of the New Brancepeth alstonite are exactly similar to those from the Brownley Hill and Fallowfield mines, though smaller in size, here averaging 2 mm., and not exceeding 4 mm., in length. They have a delicate rose-red tinge of colour, like those from the Fallowfield mine; but on exposure this colour is lost and the crystals become dull white. The form is that of an acute, six-sided pyramid. The faces are deeply striated horizontally, and are each divided into two areas by a suture running from the apex of the crystal to the median horizontal edge, the two areas forming a slight re-entrant angle across the suture-line. On the goniometer this re-entrant angle was measured as 2° 26′. Each compound face gives two bands of reflected images, which are fainter towards the horizontal edge and increasingly brighter towards the apex of the crystal. Further, the two bands show a slight divergence and curvature, being coincident at their fainter ends and showing the greatest separation (of 2° 26′) at their brighter ends. The angles

was obtained in the Great Limestone. No specimen of the mineral has been found at either Brownley Hill or Fallowfield mines for over fifty years.'

The name 'bromlite' (T. Thomson, 1837) for this species is thus based on an error, and, in spite of its priority as urged by Dana, it seems better to give preference to the more expressive name alstonite (A. Breithaupt, 1841).

[1] Calcite I have not found in the New Brancepeth vein; but it was observed in very small amount on the joint-planes of the shales, which are raised from the pit and are ground for making bricks.

between the faces, as measured for the brighter ends of these bands of light, are 50°–52° over the horizontal median edge, 129½°–131½° over the apex, and 51½°–53½° over the polar edge.

Sections of crystals cut perpendicularly to the vertical axis show a six-rayed star of colourless, transparent material, with each ray passing from the centre to a corner of the hexagon; and alternating with these there are wedges of white, cloudy material penetrating from the sides of the hexagon towards the centre. In polarized light the division into sectors is not very evident; the optic axial plane is of variable orientation in different parts of the section, being sometimes parallel to the adjacent edge of the hexagon and sometimes inclined at 30°. The double refraction is negative and strong, and the optic axial angle $2E=10°$ about.

The specific gravity is 3·67, this determination being made with the pycnometer on 1·5 gram of selected crystals. The mineral effervesces freely in cold, dilute hydrochloric acid, and the solution imparts to the Bunsen-flame, first a reddish-yellow, and then a yellowish-green coloration; no strontium could be detected with the spectroscope. A drop of the solution on a microscope-slide gives with sulphuric acid an immediate precipitate of barium sulphate, and, on evaporation, an abundant crop of gypsum needles.

Analysis[1] of 1 gram of the material used for the specific gravity determination gave:—

BaO ...	52·3,	corresponding with	$BaCO_3$ ...	67·3 per cent.[2]
CaO ...	18·0	„	„ $CaCO_3$ ...	32·1
MnO ...	0·06	„	„ $MnCO_3$ ...	0·1
Insoluble in HCl (particles of barytes)			...	0·2
				99·7

Ullmannite.

(Nickel sulph-antimonide, NiSbS.)

In recording this species as new to the British Isles, and its presence in the Coal Measures, it is interesting to recall the occurrence of millerite (NiS) in the Coal Measures of Merthyr-Tydvil in South Wales. By reason of its good cubical cleavage and bright metallic lustre, the mineral

[1] The barium was precipitated with very dilute sulphuric acid (1 in 300) and weighed as sulphate, and the calcium was precipitated as oxalate and weighed as oxide.

[2] Corresponding with the formula $BaCO_3 . CaCO_3$, the calculated values are BaO 51·56 and CaO 18·86 per cent.

presents, at first sight, a striking resemblance to galena. When, however, the two minerals are compared directly, it is soon evident that in ullmannite the cleavage is less perfect, and that the colour is tin-white to steel-grey rather than a bluish-(lead-)grey; further, ullmannite (H. = $5\frac{1}{2}$) readily scratches galena (H. = $2\frac{1}{2}$).

Two distinct types of crystals have been found:—

1. *Cubic habit.* Rough cubes measuring up to 2 cm. along their edges, and parallel groupings of cubes reaching 6 cm. across; one such polysynthetic crystal weighs 624 grams. Bright cleavage areas also frequently measure as much as 6 cm. across. The faces of the cubes are bright, but somewhat uneven, and they are usually roughly striated parallel to alternate edges, as in iron-pyrites. This striation sometimes gives place to narrow faces of the pentagonal-dodecahedron *e* {210}. Narrow faces of the rhombic-dodecahedron *d* {110} were also detected with the goniometer.

The crystals of this type occur embedded in clay, together with galena, witherite, barytes, and a little iron-pyrites. A few large lumps, several pounds in weight, were found in a single pocket in the vein.

A feature of special interest is presented by the parallel intergrowth of the ullmannite with the galena, as exhibited by the coincidence of the cleavages in the two minerals. One and the same crystal is seen to consist partly of ullmannite and partly of galena, and frequently the former is surrounded by a shell of the latter. There is no chemical analogy between ullmannite (NiSbS) and galena (PbS), but their molecular volumes are almost identical, being 31·5 and 31·9 respectively. This affords a striking example in support of Mr. T. V. Barker's contention that parallel growths of isostructural substances are conditioned by similarity of molecular volume.[1]

A determination of the specific gravity (made with the pycnometer on 2 grams of cleavage fragments of the cubic crystals separated from galena) gave the value 6·70. Analysis of this material showed the presence of sulphur, antimony (over 52 per cent.),[2] nickel (27·87 per cent.), a trace of iron, and the absence of cobalt and arsenic. The material is thus pure NiSbS. Heated in a bulb-tube, the mineral decrepitates and fuses, giving a faint white sublimate, and near the assay a reddish-yellow sublimate.

[1] T. V. Barker, Mineralogical Magazine, 1907, vol. xiv, p. 235; 1908, vol. xv, p. 42.

[2] The mineral was decomposed with fuming nitric acid, the nickel passing into solution and the antimony remaining as SbO_2, which was weighed as such (some, however, became reduced and was lost).

2. *Octahedral habit.* Small octahedra measuring about 3 mm. along the octahedral edge. The faces are bright, but rough and rounded. A few crystals are distinctly tetrahedral in their development, with larger and smaller faces in adjacent octants; but no difference could be detected in the surface characters of the larger and smaller faces, nor, indeed, could any definite system of striation be recognized.

Crystals of this type occur, together with zinc-blende, as small veins running through massive barytes; and only a few small specimens were seen.

The material possesses the same tin-white colour and good cubical cleavage as that of the cubic habit. It was tested for antimony and nickel, but was not further examined.

Two types of ullmannite, the pyritohedral and the tetrahedral, have long been known, and Principal H. A. Miers [1] has established that the mineral is really tetartohedral (tetrahedral-pentagonal-dodecahedral class). Hitherto, however, the two types have been found only at separate localities,[2] so that their association together adds another point of interest to the New Brancepeth occurrence. Although the crystals are of considerable size, they are unfortunately not sufficiently well developed for detailed crystallographic study.

Barytes.

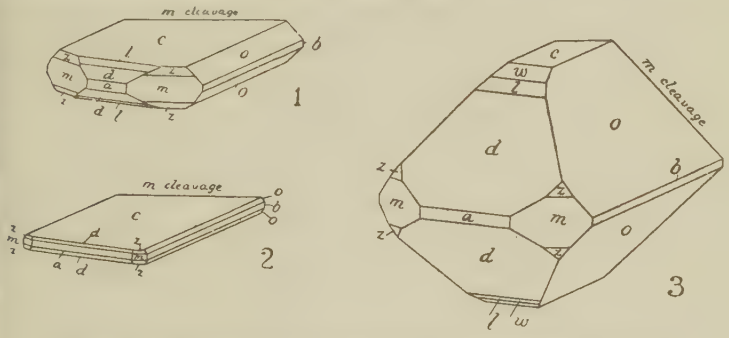
This is the most abundant mineral in the vein and in many places the only one present. It is usually massive, showing large cleavage surfaces, and is pure white and opaque, or sometimes with a yellowish tinge of colour. Small cavities lined with crystals are met with in this massive material; and crystals are also found, together with witherite, in the brecciated portions of the vein. The crystals are perfectly colourless and transparent, and sometimes of considerable size; the largest (fig. 3) I have seen measures 8 to 10 cm. in the directions of the crystallographic axes, and weighs 1027 grams. They are usually tabular in habit, parallel to the basal pinacoid (fig. 1), some of them being quite thin and resembling bevelled plates of glass (fig. 2). Less frequently the habit is prismatic in the direction of the brachy-axis (fig. 3). The common forms are a {100}, b {010}, c {001}, m {110}, o {011}, l {104}, d {102}, and z {111}. In addition to these, the above-mentioned large crystal (fig. 3) shows w {106}, and small faces of y {122}, μ {124}, n {120}, and

[1] H. A Miers, Mineralogical Magazine, 1891, vol. ix, p. 211.

[2] With the doubtful exception of Lobenstein in Thuringia, where the crystals of octahedral habit are possibly gersdorffite and not ullmannite.

three other prisms between *a* {100} and *m* {110}—a total of fifteen forms.

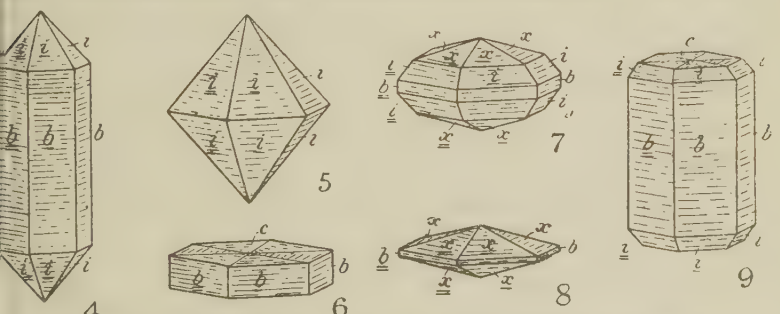
The crystals frequently show beautiful and very sharply defined etch-figures. Where intimately associated with the witherite, they are usually deeply corroded, and are sometimes represented by cellular masses incrusted with minute crystals of witherite.



FIGS. 1–3.—Crystals of barytes from New Brancepeth Colliery.

WITHERITE.

This usually forms nodular masses with a radiated internal structure and a scaly surface; their interior usually consisting of barytes, or occasionally of sandstone or coal. These masses are often of considerable size: one piece which I saw outside the mine measured 50 cm. across.



FIGS. 4–9.—Crystals of witherite from New Brancepeth Colliery.

Crystals are mainly found in cavities in the brecciated portions of the vein. They vary considerably in habit, being lenticular, pyramidal, or prismatic (figs. 4–9). The lenticular habit is the most frequent, and it is this that gives rise to the scaly surface of the nodular masses. The

lenticular form is produced by the rounding of the flat pyramid x with the basal plane, and all gradations from the form shown in fig. 8 to a flat, almost disc-shaped crystal can be traced. Lenticular crystals measuring 4 cm. in diameter have been found. In colour, the crystals are usually white or grey and almost opaque, but small crystals are often colourless and transparent. Some crystals are yellowish, and others quite black, due to the enclosure of particles of coal.

A thin section cut parallel to the base shows a division into six sectors, with twin-lamellae parallel to the diagonals of the hexagon. In each sector the optic axial plane is parallel to the external edge; the double refraction is strong and negative, and the axial angle $2E = 25°$ about. The section is, in fact, exactly as described and figured by Des Cloizeaux.[1] This optic orientation proves that the faces of pseudo-hexagonal pyramids are brachy-domes, and that those of the pseudo-hexagonal prism belong to the brachy-pinacoid. On the goniometer only approximate measurements could be obtained, owing to the deep horizontal striations and the irregularity of the faces. The best angles measured from the pseudo-hexagonal prism b {010} to the pseudo-hexagonal pyramids were 34° 24′, 53° 37′, 69° 45′, corresponding with the forms i {021}, k {011}, and x {012}. The basal plane c {001} is also sometimes present.

The witherite is clearly of later date than the barytes: small, white, button-like crystals (x i) of witherite are often attached to the water-clear crystals of barytes; small, colourless crystals encrust the cavities of corroded barytes; and the nodular witherite usually occurs as a coating on massive barytes. It is therefore probable that the witherite has been formed from the barytes by the action of carbonated waters.[2]

Galena, Zinc-blende, Copper-pyrites, and Iron-pyrites.

Metallic minerals are present in only small amount, and are of quite local distribution in the barytes vein, usually running as strings through the massive barytes.

Galena, showing large, bright cleavage surfaces, has been mentioned

[1] Des Cloizeaux's figure is copied in Dana's 'System of Mineralogy,' 6th edit., 1892, p. 284, fig. 6.

[2] In other instances where barytes and witherite are associated together, it has often been assumed that the barytes has been formed from the witherite by the action of waters containing sulphuric acid and ferrous sulphate, the latter having been produced by the weathering of iron-pyrites. This would undoubtedly account for any secondary barytes and for pseudomorphs of barytes after witherite, but probably not for the main mass of barytes in the vein.

bove as occurring in parallel intergrowth with the ullmannite. A small roup of cubo-octahedra of galena was also obtained.

Zinc-blende and copper-pyrites were detected as specks and minute rystals, usually embedded in the massive barytes, and also, less frequently, n and on the witherite.

Iron-pyrites is rather more common, though not abundant; in one lace, however, a large quantity was found in clay between barytes and itherite. It is massive, or has the form of small cubes or cubo-ctahedra.

Melanterite.

Iron-vitriol is sometimes seen as a green stain on the surface of the massive barytes. A bright green aggregate of fibres, $1\frac{1}{2}$ cm. in length, was found on the surface of shale containing iron-pyrites. This is obviously a secondary mineral derived from the iron-pyrites.

On a Meteoric Stone from Simondium, Cape Colony.

(*With Plate VII, fig.* 1.)

By G. T. Prior, M.A., D.Sc., F.G.S.

Keeper of Minerals in the British Museum.

[Read November 16, 1909.]

IN October 1907 two mineral-specimens were sent for investigation to the Mineral Department of the British Museum by Mr. R. T. Hancock, of Cardiff, who had brought them back from South Africa. On examination they proved to contain patches of olivine and troilite and particles of nickeliferous iron, and appeared therefore to be of meteoric origin. According to Mr. Hancock two 'boulders' of similar material had been found, 100 yards apart and a foot below the surface, in gravel near Simondium Station on the Paarl to French Hoek line, Cape Colony. These 'boulders', which were as much as a foot in diameter, were broken up into small fragments by the finders, who supposed the bright particles of metallic iron exposed on the fractured surfaces to be silver. Another fragment of the meteorite was subsequently presented to the Museum Collection by Mr. Hancock, and still later three other pieces were sent by Mr. R. H. Stanley, of Paarl, one of the two prospectors who originally found the masses. According to Mr. Stanley, three 'boulders' altogether had been found in a deposit of ironstone-gravel.

In support of the meteoric origin of these masses is the fact that no basaltic rocks occur in the neighbourhood of Simondium, but only superficial deposits, such as the gravel, in which they were found, and, to the west, the slates, with intruded granites, of the Malmesbury series.

The total weight of the six fragments of the meteorite now in the British Museum Collection is 987 grams, the largest weighing 445 grams and the smallest 41 grams. All of them are much weathered and rusted on the surface, and are decomposing owing to the presence of chloride of iron. Fractured surfaces are dark grey and show sparsely distributed small particles of nickeliferous iron. All the fragments show scattered masses of olivine, one of which is more than two inches in length; one fragment contains a mass of troilite about a half-inch in length.

The meteorite belongs to the less common class of aerolites which

how no chondritic structure and approach in characters most closely to terrestrial basalts. It consists mainly of enstatite, olivine, and felspar, with magnetite and nickel-iron, and may be referred to the howardite group of Brezina to which the Petersburg and Frankfort stones belong.

In thin slices under the microscope (Plate VII, fig. 1; magnification 50 diameters), particles of metallic iron (to a large extent oxidized), large rounded porphyritic olivines, and smaller irregular colourless enstatites are seen in a base consisting of granular and small prismatic enstatites, lath-shaped felspars, and grains of magnetite: whether any monoclinic pyroxene is present in the base is doubtful; all the grains showing definite prismatic outline which were examined gave straight extinction. The large phenocrysts of olivine show numerous small, dark brown inclusions, which for the most part are irregularly distributed, but sometimes are accumulated along parallel lines, making generally an angle of about 13° with the direction of extinction. The large sections of enstatite show well-marked, prismatic cleavage with straight extinction; they are often dense with inclusions of minute grains of magnetite, but show no traces of chondritic structure. The felspar-laths show albite- and occasionally pericline-twinning, and consist of labradorite to anorthite with symmetrical extinction about the albite twin-lamellae of over 30°. Some of the larger sections have a pinkish tinge and are crowded with dusty inclusions like the felspars in the Juvinas meteorite. The nickel-iron, as seen on a polished surface, is in small grains generally less than a millimetre in diameter and not very thickly distributed: qualitative analysis showed the presence of nickel in fair amount.

Owing to the rusted condition of the meteorite no quantitative analysis of it was attempted. A chemical analysis, however, was made of the olivine, with the following result under I:—

		I. (Simondium)		II. (Brenham Township)
SiO_2	...	39·22	...	40·70
Fe_2O_3	...	2·59	...	0·18
FeO	...	8·26	...	10·79
NiO	...	—	...	0·02
MnO	...	—	...	0·14
MgO	...	48·79	...	48·02
H_2O	...	0·47	...	—
		99·33		99·85

This analysis was made on 0·9886 gram of material, of which the specific gravity was 3·33. The numbers obtained show that the olivine is very similar in composition to the olivine in the pallasite of Brenham Township, Kiowa Co., Kansas, the analysis of which is given under II [1].

[1] L. G. Eakins, Amer. Journ. Sci., 1890, vol. xl, p. 315.

On an Analcite-basalt from Rathjordan, Co. Limerick.

(*With Plate VII, figs.* 2 *and* 3.).

By G. T. Prior, M.A., D.Sc., F.G.S.

Keeper of Minerals in the British Museum.

[Read January 25, 1910.]

AMONGST the rock-specimens from Co. Limerick belonging to the Allport Collection in the British Museum, a specimen of basalt from Rathjordan, Co. Limerick, attracted attention by the fact that, in thin slices under the microscope, it showed small, round sections of isotropic material containing central and octagonally arranged, marginal inclusions, and thus resembling leucite.[1] The rock from Rathjordan has been described by Hull[2] and by Allport.[3] According to Allport the rock is a columnar, fine-grained, black basalt which occurs interbedded with ashes, and consists of 'innumerable small grains of augite and magnetite set in an amorphous glass, the whole forming a matrix in which serpentinous pseudomorphs of olivine and felspar are porphyritically imbedded'.

To this description it is only necessary to add, in the case of the Museum specimen, that augite also occurs as phenocrysts and, like the small, prismatic augites of the base, is of the purplish titaniferous variety, and that the supposed glassy matrix, which is clear and colourless, encloses minute needles (probably of apatite) and in many parts of the slide forms the minute, round sections, with inclusions, mentioned above. These sections, with their central and marginally arranged inclusions of the augite and magnetite of the base, strikingly resemble

[1] Similar characters were shown by thin slices of rocks from 'hill above Hicker, one mile south-west of Pallas Station, Co. Limerick', kindly placed at my disposal by Professor Grenville A. J. Cole and Professor H. J. Seymour.

[2] E. Hull, Geol. Mag., 1873, vol. x, p. 157 and Plate VIII, fig. 9.

[3] S. Allport, Quart. Journ. Geol. Soc., 1874, vol. xxx, p. 552.

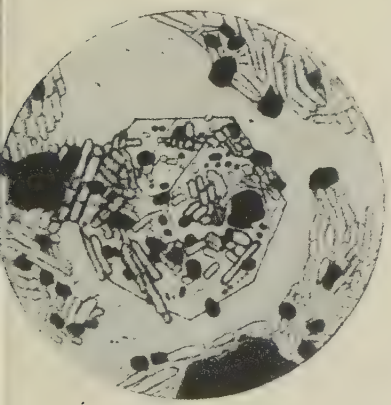
small leucites such as occur in the leucite-basalts of the Bohemian Mittelgebirge. The rock itself is indeed very similar to these leucite-basalts (e. g. the rock from the Dobernberg, Tetschen, Mittelgebirge) in all respects, except that in the Bohemian rocks the olivine is for the most part unaltered. Two of the leucite-like sections are represented in Plate VII, figs. 2 and 3, highly magnified (in fig. 2 about 150 diameters, in fig. 3 about 300 diameters). In most of the round sections, such as that represented in fig. 3, the material containing the central and marginal inclusions is not distinguished in any other way from the rest of the isotropic matrix, but in a few, one of which is represented in fig. 2, this material is seen to be marked off from the surrounding isotropic base by a distinct octagonal outline.

In order to investigate more closely the nature of the isotropic material, an attempt was made to isolate some of it by powdering the rock (so that the particles passed through a sieve with 110 meshes to the inch) and separating the lighter portion by immersion in methylene iodide diluted with benzene. Only a very small amount of material was separated in this way; but under the microscope it showed several small flakes of the clear, isotropic material. When tested by the Becke method, most of the flakes appeared to have a refraction less than that of cedar-wood oil (1·505) and nearer to that of xylene (1·487). Examination of sections on the edge of an uncovered thin slice of the rock gave somewhat variable results; the first observations appeared to show that one section at least had a refraction near to that of benzene, but this was not confirmed by later observations, made on other sections, which agreed with those made on the thin flakes separated by heavy liquids. Further, the solution in hydrochloric acid of some of these flakes deposited on evaporation numerous cubes of salt and gave a strong sodium-line in the spectrum and no indication of a potassium-line. It appeared, therefore, that most, at any rate, of the isotropic material could be better referred to analcite than to leucite. In order to test this conclusion, a quantitative determination was made of the alkalis, and eventually of most of the other constituents of the rock. The result of that analysis is given under I: for comparison, under II is given the analysis of a leucite-basalt from the Dobernberg, Bohemian Mittelgebirge,[1] with which the Limerick rock presents such striking similarities; and under III the analysis of an analcite-basalt from Colorado described by Whitman Cross.[2]

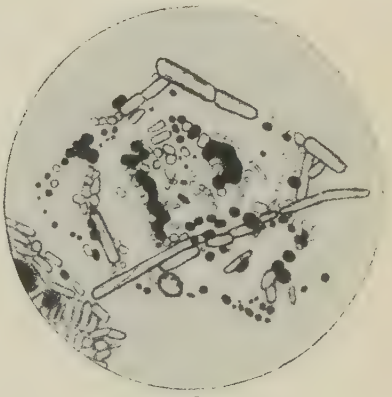
[1] F. Pfohl in J. E. Hibsch, Min.-Petr. Mitt. (Tschermak), 1894, vol. xiv, p. 111.
[2] W. Cross, Journ. Geol. Chicago, 1897, vol. v, p. 689.

1.

G. T. PRIOR: METEORIC STONE FROM SIMONDIUM, CAPE COLONY.



2.



3.

G. T. PRIOR: ANALCITE-BASALT FROM RATHJORDAN, CO. LIMERICK.

	I. (Rathjordan)	II. (Bohemia)	III. (Colorado)
SiO_2	40·81	44·16	45·59
TiO_2	3·86	2·06	1·32
Al_2O_3	13·08	12·96	12·98
Fe_2O_3	6·40	8·07	4·97
FeO	7·20	3·10	4·70
MnO	0·07	—	0·14
CaO	10·12	12·26	11·09
MgO	10·03	10·83	8·36
Na_2O	2·43	1·92	4·53
K_2O	0·31	0·72	1·04
P_2O_5	0·88	1·03	0·91
H_2O at 110° C. ...	0·82	·0·46	0·51
H_2O above 110° C.	3·97	2·41	3·40
	99·98	99·98	99·54

The small fractional percentage of potash obtained in this analysis certainly tends to confirm the conclusion already drawn that most, at any rate, of the isotropic material consists of analcite and not of leucite. Analcite as a rock-forming mineral has been described in the teschenites of Moravia, in monchiquite-like rocks such as the one investigated by J. W. Evans from Mount Girnar, Junagarh, India,[1] and as a primary constituent in basalts from Montana [2] and Colorado.[3] In the rock from Colorado, described by Whitman Cross, no crystalline form was observed, but rings or wreaths of small inclusions were noticed in a few grains, so strongly suggesting leucite that the rock was at first considered to be a leucite-basalt. In the case of these basalts, argument for the primary nature of the analcite is drawn from the freshness of the other constituents. To the basalt from Rathjordan no such argument is applicable, for the rock is of Carboniferous age and has suffered much alteration. It is just conceivable that the rock was originally a leucite-basalt, and that the leucites have been for the most part subsequently altered to analcite, as is suggested by Rosenbusch for the above-mentioned analcite-basalt or monchiquite from Montana described by Lindgren. Judging from the low percentage of potash in the analysis (II) of the leucite-basalt from Bohemia, it seems probable that in this rock also a similar alteration of most of the leucitic material to analcite may have taken place.

[1] J. W. Evans, Quart. Journ. Geol. Soc., 1901, vol. lvii, p. 38.

[2] W. Lindgren, Proc. Calif. Acad. Sci., 1890, ser. 2, vol. iii, p. 51.

[3] W. Cross, Journ. Geol. Chicago, 1897, vol. v, p. 684.

Notes on the weight of the 'Cullinan' diamond, and on the value of the carat-weight.

By L. J. Spencer, M.A., F.G.S.

Assistant in the Mineral Department of the British Museum.

[Read January 25, 1910.]

THE history of famous diamonds has always been surrounded with mystery and uncertainty, and this is no less the case with the recently-discovered 'Cullinan', by far the largest of all diamonds, which was found in the Premier diamond mine, near Pretoria, in the Transvaal, on January 25, 1905. Whilst it is now no longer possible to arrive at the exact facts respecting the earlier-found stones, it is desirable to place on record any definite information respecting the more noteworthy stones found in our own time.

In the case of the 'Cullinan' a doubt exists not only as to the statement of its weight in carats, but also as to the exact equivalent, compared with standard weights, of the carat-weights in which this is expressed.

In the first of the two following tables the weight, as variously expressed in carats,[1] is quoted; and in the second the still more divergent values expressed in standard weights.

Carats.	
3,032	'The Times' and other London daily papers of January 28, 1905.
	'Nature,' February 16, 1905, vol. lxxi, p. 372.
	Sir A. H. Church, 'Precious Stones,' New edition, 1905, p. 57; and 3rd edit., 1908, p. 58.
	L. Claremont, 'The gem-cutter's craft,' 1906, pp. 98, 115.
3,030	'Daily Telegraph,' January 28, 1905.
	Centralblatt für Mineralogie, &c., March 1, 1905, p. 153.
3,024¾	Dr. F. H. Hatch, Quart. Journ. Geol. Soc., 1905, vol. lxi, proc. p. lxxxix (meeting of March 8, 1905).
	Drs. F. H. Hatch and G. S. Corstorphine, Trans. Geol. Soc. South Africa, 1905, vol. viii, p. 26 (read March 13, 1905); Geological Magazine, April, 1905, vol. ii, p. 170; Mineralogical Magazine, 1905, vol. xiv, p. 119; 'Geology of South Africa,' 1905, p. 275, and 2nd edit., 1909, p. 270.

[1] In all these instances the weight is presumably expressed in English carats, but only in the article in 'The Times' of November 10, 1908, is this expressly stated.

Carats.

Dr. G. A. F. Molengraaff, Trans. Inst. Mining Engineers, 1906, vol. xxix, p. 507.

R. A. F. Penrose, 'The Premier diamond mine, Transvaal.' Economic Geology, 1907, vol. ii, p. 280.

Premier (Transvaal) Diamond Mining Co., Ltd., Report for the year ended October 31, 1905, Johannesburg, 1905.

Prof. Max Bauer, 'Edelsteinkunde,' 2nd edit., 1909, p. 321.

Dr. W. Goodchild, 'Precious stones,' 1908, p. 140.

A. P. Karpinsky, Verh. Russ. Mineral. Ges. St. Petersburg, 1905, vol. xliii Protoc., p. 37.

Mineral Industry (New York), for 1905 (1906), vol. xiv, p. 214; for 1906 (1907), vol. xv, p. 671.

Dr. F. Krantz, of Bonn, in pamphlet issued in 1908 with glass models.

Plateelbakkerij 'De Distel,' of Amsterdam, in pamphlet issued in 1909 with glass models.

British Museum (Natural History), General Guide, 12th edit., 1909, p. 91.

3,024½ Dr. G. F. Kunz, Annual Report on Precious Stones for 1904, in Mineral Resources of the United States, 1905, p. 947.

3,024 Dr. G. F. Kunz, ditto for 1905, ibid., 1906, p. 1329.

'Standard,' March 16, 1905.

3,025 'Daily Mail,' April 5, 1905.

3,025¾ Sir W. Crookes, MS. note with photographs shown at the Royal Society Conversazione on May 17, 1905; British Association lecture at Kimberley (September 5, 1905), in Chemical News, 1905, vol. xcii, p. 139, and reprint (London, 1905), p. 16; 'Diamonds,' 1909, p. 77. [The stone was examined and photographed, though not weighed, by Sir W. Crookes at the London office of the Premier Company in April, 1905. The statement of the weight was printed on the base on which the stone stood].

'The Times,' November 10, 1908 [in a long article giving the history of the stone and an account of its cutting].

Harrod's Stores, London, label with glass models sold in large numbers in 1909.

L. J. Spencer, Proc. Geologists' Association, 1909, vol. xxi, p. 159; English translation of Prof. R. Brauns's 'The Mineral Kingdom,' 1910, p. 211.

3253¾ J. Wodiska, 'A book on precious stones,' New York, 1909, pp. 52, 54.

The first weighing of 3,032 carats was probably made at the mine before the stone had been thoroughly cleaned; that of 3,024¾ was made at the Johannesburg office of the Premier (Transvaal) Diamond Mining Company, Ltd.; and that of 3,025¾ at the London Diamond Office of the Company.

In addition to the above, some other, and so far as I know unpublished, weights in carats may be here given. On the arrival of the stone in London it was weighed by Mr. S. Neumann at the offices of the

Premier Company, and in his letter of acknowledgement of March 31, 1905, he stated the weight to be 3,025½ carats, at the same time drawing attention to the difference of ¾ carat between his weighing and the weighing in Johannesburg.[1] The value 3,025¾ carats is the result of a more careful weighing made in April, 1905; and this weight is recorded on an engraved silver tablet accompanying the glass model of the 'Cullinan' presented by the Premier Company to the British Museum in 1906. Messrs. I. J. Asscher & Co., of Amsterdam, by whom the stone was so advantageously cut, have been good enough to inform me that their record of the weight of the original stone is 3,019¾ Dutch carats, or 3,025 English carats.

Coming now to the published statements of the weight of the 'Cullinan' as expressed in standard weights, we find :—

English avoirdupois.	
9,600·5 grains = 1·37 lb.	Drs. Hatch and Corstorphine (loc. cit.).
9,586·5 „ = 1·37 lb.	Sir W. Crookes (loc. cit.).
about 22 oz.	'Daily Telegraph,' January 28, 1905.
nearly 1½ lb.	'Nature' (loc. cit.).
slightly over 1½ lb.	'Daily Mail,' March 27, 1905.
1¼ lb.	'Daily Mail,' April 5, 1905.
over 1⅓ lb.	'The Times,' November 10, 1908.
about 1¾ lb.	British Museum Guide (loc. cit.).

Grams.	
676½	'Nature' (loc. cit.).
621½	Sir A. H. Church (loc. cit.).
620	Dr. F. Krantz (loc. cit.).
	Dr. P. A. Wagner, 'Die diamantführenden Gesteine Südafrikas,' 1909, p. 123.
610	Prof. Max Bauer (loc. cit.).

The equivalent of 9,600·5 English grains given by Drs. Hatch and Corstorphine was calculated from the value of the 'South African carat' (3·174 grains) quoted from Mr. Gardner F. Williams.[2] Such a value

[1] This difference between the weighings in Johannesburg and in London is considerably greater than might be accounted for by a correction of the weight of displaced air and the height of the barometer, and, moreover, is in the opposite direction. The stone would weigh more—that is, be less buoyed up—in the more rarefied air of Johannesburg; the difference (with brass weights) being about 0·014 gram or slightly more than $\frac{1}{16}$ carat.

[2] G. F. Williams, 'The diamond mines of South Africa,' 1902, p. 520; new edition, 1906, vol. ii, p. 160. Here we find the curious statement (copied from E. W. Streeter, 'The great diamonds of the world,' 1882, p. 35) that the carat is 'equivalent to 4 grains avoirdupois or 3·174 grains troy weight'. Grains avoirdupois and grains troy are, of course, identical. The confusion is no doubt

for the carat would correspond with 205·672 milligrams, and the weight of the original stone would be 622·10 grams. On the other hand, the value of the carat calculated from the weights given by Sir W. Crookes (3,025¾ carats = 9,586·5 grains) is 205·303 milligrams, with 621·20 grams as the weight of the original stone.

A calculation from the weighing in Dutch carats (3019¾) gives still another result. In the books I have found no less than seven different values given for the Dutch carat; taking that adopted by the Association of Diamond Workers in Amsterdam on October 17, 1890 (namely, 1 kilogram = 4,875 carats, or 1 carat = 205·128 milligrams), the weight is 619·44 grams.

An attempt was made to arrive at the weight of the original stone by determining the volume of the models, by weighing them in air and water. Three glass models (which, as seen from the markings on the surface, must have been cast in as many different moulds) had volumes of 170·05 cubic centimetres, 173·19 c.c., and 178·97 c.c. Taking the specific gravity of diamond to be 3·52, the corresponding weights would be 598·56, 609·62, and 629·98 grams respectively.

The only method, therefore, of arriving at the weight of the original 'Cullinan' was to compare with known weights the actual carat-weights against which the stone itself had been weighed. In this direction every facility has been most courteously given to me by Mr. W. Busch, the manager of the London Diamond Office of the Premier (Transvaal) Diamond Mining Company, Ltd., and to him I desire in this place to express my thanks.

The 3,000 carat-weight in use at this office I found to be equivalent to 615·88 grams; hence 1 carat = 205·293 milligrams, which multiplied by 3,025¾ gives 621·17 grams. A dummy weight (of shot in a canister) was made up to this amount, and checked, first in one pan and then in the other, against the carat-weights (3,000 and 2,000 + 1,000) on the same balance on which the 'Cullinan' itself had been weighed. With this load the balance was sensitive to ¼ carat, or about 0·05 gram.

These carat-weights show considerable signs of wear, owing to the rough usage to which they are subjected; and it is probable that nearly five years ago, at the time of the weighing of the 'Cullinan', they were appreciably heavier. The weights were supplied by Messrs. De Grave, Short & Co., of Hatton Garden, London, who inform me that the

due to the division of the carat into 4 'diamond-grains'. We also have the 'pearl-grain', 600 of which equal one ounce troy. Such are the pitfalls of the English system of weights and measures!

standard they take for the English carat is 205·3 milligrams. Taking 205·304 (see below), this gives when multiplied by 3,025¾ the value 621·199 grams.

We may therefore safely place the weight[1] of the 'Cullinan' diamond in its original uncut form at

621·2 grams.

This is equivalent to 9,586½ English grains[2] (exactly as given by Sir William Crookes), or 1·3695 lb. avoirdupois, or nearly 1 lb. 6 oz. avoirdupois.

When expressed in carats, it is not sufficient to state that the weight is 3,025¾ English carats. It must at the same time be stated that the carat is one of 205·304 milligrams, as defined by the Standards Department of the Board of Trade[3] in 1888 and 1889; namely 1 ounce troy of 480 grains = 151½ carats, or 1 carat = 3·1683 grains.

The weights of the brilliants cut from the 'Cullinan' diamond are given in [English] carats in the article in 'The Times' of November 10, 1908; and Messrs. I. J. Asscher & Co., of Amsterdam, have kindly supplied me with a statement of the weights in Dutch and English carats, as quoted in the following table. I find that these weights are in agreement when the Dutch carat is taken as one of 205·712 milligrams[4] and the English carat one of 205·304 milligrams.

No.		Dutch carats.	English carats.	Grams.
1	Pendeloque brilliant	$515\frac{1}{2}$	$516\frac{1}{2}$	106·04
2	Oblong ,,	$308\frac{5}{8}$	$309\frac{3}{16}$	63·48
3	Pendeloque ,,	$91\frac{3}{4}$	92	18·89
4	Square ,,	$61\frac{7}{8}$	62	12·73
5	Heart-shaped ,,	$18\frac{3}{8}$	$18\frac{3}{8}$	3·77
6	Marquise ,,	$11\frac{1}{4}$	$11\frac{1}{4}$	2·31
7	,, ,,	$8\frac{9}{16}$	$8\frac{9}{16}$	1·76
8	Oblong ,,	$6\frac{5}{8}$	$6\frac{5}{8}$	1·36
9	Pendeloque ,,	$4\frac{9}{32}$	$4\frac{9}{32}$	0·88
10	96 small brilliants	$7\frac{3}{8}$	$7\frac{3}{8}$	1·51

The total weight of the 9 larger and the 96 smaller cut stones is

[1] That is, the weight in air against brass weights. The absolute weight *in vacuo* would be about 621·33 grams, or about $\frac{5}{8}$ carat more.

[2] 1 gram = 15·43235 English grains.

[3] Weights and Measures—Report by the Board of Trade on their proceedings and business under the Weights and Measures Act of 1878; for 1888, p. 13; for 1889, p. 2.

A verbatim reprint of these statements is given by Mr. E. J. Vallentine in his recent paper, 'The carat weight.' Trans. Inst. Mining and Metallurgy, London, 1908, vol. xvii, pp. 430–434. Unfortunately he gives the equivalent in milligrams as 205·3022 instead of 205·304.

[4] Calculated from 3,019¾ Dutch carats = 621·20 grams (see above, p. 320).

1,036$\frac{5}{32}$ English carats, or 212·73 grams, corresponding to a yield from the rough stone of 34$\frac{1}{4}$ per cent.

Although it is well-known and recognized that the carat-weight varies in different countries and places[1], it does not appear to be generally known that there are slight differences in the English carat.[2] The value more usually given in the books on precious stones for the English carat is 205·409 milligrams, which multiplied by 3,025$\frac{3}{4}$ would give 621·52 grams for the weight of the 'Cullinan'.

In this connexion I have compared against gram-weights, eight different sets of carat-weights actually in use in London, obtaining values for the carat varying from 203·2 to 206·3 milligrams (a difference of about $\frac{1}{64}$ carat), the majority being, however, somewhere near 205·3 milligrams. This is perhaps not altogether surprising when one considers that the weights are not handled with any degree of care; and that, being cheap commercial weights for weighing to only $\frac{1}{64}$ carat (= 3·2 milligrams), they are not accurately adjusted. The more carefully handled and adjusted set of carat-weights in the Mineral Department of the British Museum correspond with 1 carat = 205·410 milligrams. This set was supplied by Mr. L. Oertling about the year 1851, but the carat-weights he now makes agree with the Board of Trade definition (205·304 mg.).

The carat[3] is a very ancient unit of weight, and was formerly used for weighing gold as well as diamonds and precious stones. The Greek weight κεράτιον (*ceratium*) and also the Roman siliqua were equivalent to $\frac{1}{144}$ ounce or 3$\frac{1}{3}$ grains of our present weights; that is, only slightly more than the present value of the carat (about 3$\frac{1}{6}$ grains).

Boetius de Boodt[4], Tavernier, and other writers in the seventeenth century mention that the carat (*ceratium*) is divided into four grains [these grains being, however, 'carat-grains', 'diamond-grains', or 'pearl-grains', and not the ordinary grain]. In 1750 David Jeffries[5] states that '150 carrats make about 1 ounce troy': this value of the carat is

[1] e. g. from 188·6 mg. in Bologna to 215·99 mg. in Livorno (to quote once more the statements that are copied from one book to another).

[2] This was clearly pointed out by Sir A. H. Church in 1883 ('Precious Stones,' 1st edit., p. 50).

[3] The term carat as used to express the fineness of gold, expresses merely a ratio (so many parts in 24), and is now quite distinct from carat-weight. The fact that the Roman siliqua was $\frac{1}{24}$ of the golden solidus of Constantine suggests a connexion between these two meanings of the word carat.

[4] A. Boetius de Boodt, 'Gemmarum et lapidum historia,' Hanoviae, 1609, p. 65.

[5] D. Jeffries, 'A treatise on diamonds and pearls,' London, 1750, p. i.

equivalent to 207·357 milligrams. J. Mawe[1] in 1823 gives 151¼ carats = 1 ounce troy; and P. Kelly[2] in 1835 gives 151½ English diamond carats = 1 ounce troy. There thus seems to have been a tendency for the carat-weight to decrease slightly in value in the course of time; and a further slight decrease will bring it to the metric carat to be mentioned below.

Since the carat-weight had its origin in the use of certain hard leguminous seeds, I thought it would be of interest to ascertain the average weight of such seeds. Fifty seeds taken at random were weighed together, with the following results :—

	Average weight per seed in grams.
Seeds of *Ceratonia Siliqua* (Linn.) ... ... (Chocolate-brown seeds of a flattened pyriform shape.)	0·197
„ *Erythrina Corallodendron* (Linn.) ... (Orange-red with black spot at one end; reniform.)	0·197
„ *Adenanthera pavonina* (Linn.) ... (Crimson; lenticular.)	0·274
„ *Abrus precatorius* (Linn.) ... ... (Scarlet with black spot at one end; ovoid.) This constitutes the Indian rati, and is used at the present day by the Indian goldsmiths for weighing gold.	0·094

The first two of these weights (0·197 grams = 3·04 English grains)[3] approximate very closely to the present value of the carat-weight.

Ceratonia Siliqua is the carob or locust-tree, the fruit of which is the well-known locust-bean or St. John's bread. The Greek name κεράτιον refers to the horn-like shape of the fruit-pods; and carat is an obsolete English name for the seed. The seeds are remarkably constant in weight, and those taken from the ends of the pulpy pods are not smaller than those taken from the middle. They would be quite suitable for use as approximate natural weights for weighing small objects. Both by their weight and their name it is at once suggested that they are the origin of the carat-weight (κεράτιον, *ceratium*), and probably also of the Roman siliqua.

[1] J. Mawe, 'A treatise on diamonds and precious stones,' 2nd edit., London, 1823, p. 2.

[2] P. Kelly, 'The Universal Cambist,' 2nd edit., London, 1835, vol. i, p. 220.

[3] Sir A. H. Church ('Precious stones,' 1883, p. 49, and later editions) gives 3⅕ grains as the average weight of the seeds of *Ceratonia Siliqua*.

Another suggested origin of the carat is from 'kuara[1]', a native African name for a species of *Erythrina* or coral-tree. This seems less probable; and I find that the seeds of various species of *Erythrina* are not so constant in size and weight as those of *Ceratonia Siliqua*.

We thus see that the carat is a very indefinite unit of weight, and this is all the more surprising when we consider that it is used exclusively for the weighing of such valuable objects as precious stones. It would surely be to the advantage of gem-merchants and jewellers if some definite standard were universally adopted. The carat is clearly a useful commercial unit, since precious stones are not of any considerable size, and those in common use rarely exceed one or two carats in weight. To express these small amounts in terms of some larger unit (e. g. a gram) would be less convenient in the trade. What is wanted is a unit of weight of approximately the same value as the present carat, but one which bears some definite relation to standard weights.

Attempts to standardize the carat-weight have so far not met with much success. An 'international carat' of 205 milligrams was proposed in 1871 by the Syndical Chamber of Jewellers, &c., in Paris, and accepted in 1877 by the Syndical Chamber of Diamond Merchants in Paris.

A **metric carat** of 200 milligrams, that is exactly one-fifth of a gram (= 3·08647 English grains), has often been suggested, and has recently been definitely proposed by the International Committee of Weights and Measures[2], and accepted at the fourth sexennial General Conference of the Metric Convention[3] held in Paris in October, 1907.

[1] James Bruce ('Travels to discover the source of the Nile in the years 1768–73,' Edinburgh, 1790, vol. v, p. 65 and plate) describes the tree called 'kuara', which takes its name from the province of Kuara in Abyssinia, a name that also signifies sun. He mentions that the bean or seed is called carat, and that it is used for weighing gold in Africa and diamonds in India. This is the species *Erythrina tomentosa* (R. Brown). Two rather withered seeds of this species, collected in Abyssinia in 1868, I found to weigh 0·106 and 0·119 gram respectively, that is, only slightly over half a carat.

The species *E. abyssinica* (mentioned in Professor Max Bauer's 'Edelsteinkunde,' 1896, p. 120, 2nd edition, 1909, p. 124, and English translation by L. J. Spencer, 1904, p. 103) is perhaps a synonym of *E. tomentosa*. For assistance in botanical details I have to thank my colleague Mr. E. G. Baker of the Botanical Department.

[2] Comité international des Poids et Mesures, Procès-verbaux des séances, Paris, 1907, sér. 2, vol. iv, p. 192. (See also 1905, vol. iii, p. 124.)

[3] Quatrième Conférence générale des Poids et Mesures, Comptes rendus des séances, Paris, 1907, p. 60.

See also C. E. Guillaume, 'Les récents progrès du système métrique.' Travaux et Mémoires du Bureau international des Poids et Mesures, Paris, 1907, vol. v,

The adoption of the metric carat would be an excellent solution of the problem, and by its universal use the existing confusion would be avoided. The difference between the old and the new units is only slight, the metric carat being approximately $2\frac{1}{2}$ per cent. less than the present carat. This means that the weight of a particular stone would be expressed by a slightly larger number when weighed against metric carats than when it is weighed against the present carat-weights. At the same time a further advantage would be gained by discarding the awkward fractions $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, $\frac{1}{16}$, $\frac{1}{32}$, $\frac{1}{64}$ in favour of decimal fractions (tenths and hundredths).

For example, a stone of

$$2\tfrac{1}{8}\ \tfrac{1}{16}\ \tfrac{1}{64} \text{ English (Board of Trade) carats}$$
$$= 0{\cdot}452 \text{ gram}$$
$$= 0{\cdot}452 \times 5 = 2{\cdot}26 \text{ (approx. } 2\tfrac{1}{4}\text{) metric carats,}$$

and a stone of

$$100 \text{ English (Board of Trade) carats}$$
$$= 20{\cdot}5304 \text{ grams}$$
$$= 20{\cdot}53 \times 5 = 102{\cdot}65 \text{ metric carats.}$$

The use of the metric carat has recently been made compulsory by law in France; but unfortunately the movement for its general adoption receives little support in England. It may be added that the English carat is not a legal unit of weight under the Weights and Measures Act of 1878, but that presumably the metric carat would be covered by the Weights and Measures (Metric System) Act of 1897.

pp. 62–66 ('La réforme du carat') of the separately issued reprint, Paris (Gauthier-Villars), 1907. A notice of this appeared in 'Nature,' 1908, vol. lxxvii, p. 611.

These recommendations are mentioned in the Weights and Measures Reports (1908, p. 4; 1909, p. 4) of the Board of Trade in London; and also in the paper by E. J. Vallentine quoted above.

REVIEWS.

Edelsteinkunde, eine allgemein verständliche Darstellung der Eigenschaften, des Vorkommens und der Verwendung der Edelsteine, nebst einer Anleitung zur Bestimmung derselben, für Mineralogen, Edelsteinliebhaber, Steinschleifer, Juweliere. By Dr. MAX BAUER. 2nd edition. Pp. xvi + 766, with 21 plates and 115 text-figures. (Leipzig: Chr. Herm. Tauchnitz. 1909. Price 30 Marks.)

The first edition[1] of Professor Max Bauer's well-known work on precious stones, which appeared in 1896 and was translated into English by Mr. and Mrs. L. J. Spencer in 1904, has come to be recognized as the standard work on the subject. The author is to be heartily congratulated, not only on the reception that the first edition has met with, but also on the completion of the still more exhaustive work now before us. The general plan of the book remains exactly as before; that it has been extensively revised and brought up to date is at once evident from an increase of 55 pages of text, and the addition of 21 new text-figures and one new plate (representing the 'Cullinan' diamond, which has been discovered since the first edition appeared).

Besides collecting all the available information respecting precious stones from the rather scattered mineralogical literature of the last thirteen years, the author has obtained at first hand, from workers in the trade and from persons acquainted with the gem-mining districts, other information of practical importance and of scientific interest. We find, for example, much that is new concerning the emerald mines of Muzo, in Colombia; the diamond mines of South Africa; the tourmaline mines of San Diego Co., in California; and the occurrence of the variously coloured gem-minerals in Minas Geraes, Brazil. We also find mention of the new Californian gem-mineral benitoite; the occurrence of peridot in the Island of St. John in the Red Sea; and the interesting artificial rubies and other colour-varieties of corundum, which are now made in large quantities.

More importance is now very rightly given to the determinative value of the optical characters of gem-minerals, and in the introductory portion of the book we find illustrations explaining the use of the refractometer, with the aid of which the refractive indices of faceted stones can be so

[1] A review of the first edition appeared in this Magazine, vol. xi, p. 220.

readily determined. On the other hand, the useful optical phenomena to be observed in convergent polarized light are not made use of; but this, it is explained, is because no simple and convenient instrument is available for the use of jewellers and persons other than the mineralogist.

There is only one point which perhaps calls for criticism. The coloured plates, which have been reproduced for the new edition, do not quite reach the high standard of excellence of those issued with the first edition.

The book is very clearly printed on good paper, and is issued in fifteen parts at the price of 2 Marks per part.

La Vallée de Binn (Valais). Étude géographique, géologique, minéralogique et pittoresque. Par Léon Desbuissons. Pp. viii + 328, with 24 plates and maps, and 34 text-figures. (Lausanne: Georges Bridel & Cie. 1909. Price 10 francs.)

The author is to be congratulated on the production of this most fascinating volume, descriptive of a district which has long been of especial interest to mineralogists. Instead of being merely a dry catalogue or list of minerals and mineral localities, it is clothed with a living interest, and it may very well serve as a model for future works on topographical mineralogy. The charming views of scenery, for the most part reproduced from the author's photographs and sketches, add much to the interest of the volume, and give the reader a vivid idea of the conditions under which the minerals are found. We find chapters devoted to the geography, geology, and history of the valley, the manners and customs of the people, of excursions that may be made in the neighbourhood, together with hints to collectors, a glossary of local names, and, in an appendix (by Dr. A. Binz), a list of plants found in the valley. Professor A. Lacroix, in the preface he writes for the volume, expresses regret that the increasing technicalities of mineralogical science have the tendency to discourage the natural history study of minerals by amateurs and keen collectors of the now rare type to which the author belongs.

Chapter III is devoted to mineralogy, 42 pages being occupied with a description of the several localities, and 96 pages to a description of the individual species (65 in number) which have so far been recorded. These descriptions are not burdened with too much technical detail, but full references to the literature are given under each species. Instead of idealized geometrical drawings of crystals, we have excellent photographic reproductions of actual specimens. The most remarkable and

widely known occurrences are those in the white, crystalline dolomite quarried in the bed of the Lengenbach, and in the mica-schist and gneiss of the Alpe Lercheltini. In the Lengenbach quarry 46 species have been found, 23 of which are peculiar to this spot; nowhere else have such beautifully crystallized but highly complex minerals of the sulph-arsenite group been found. Many of the discoveries here have been made by Mr. R. H. Solly and Professor H. Baumhauer, both members of this Society. Since Mr. Solly commenced, in 1898, his annual visits to this spot he has by his enthusiasm and energy reaped a rich harvest, no fewer than 28 species new to the locality, and many of them new to science, having been collected.

A very complete index adds much to the usefulness of the volume for purposes of reference. The full bibliographical lists are rather scattered throughout the volume under the different sections, and it would perhaps have been more convenient had they been duplicated in one general list.

The Geology of Ore Deposits. By H. H. Thomas and D. A. MacAlister. Pp. xi + 416, with 65 text-figures. (London: E. Arnold. 1909. Price 7*s.* 6*d.* net.)

The scientific study of ore-deposits has within recent years been much cultivated in the United States and in Germany, and several books on this important subject have appeared; but in England the only books we have are the larger treatise of J. A. Phillips (1884, and 2nd ed. by H. Louis, 1896) and the much smaller 'Text-book of Mining Geology' by J. Park (1906 and 1907). A brief and readable account of the subject showing the present state of its development would therefore be particularly acceptable. The present work fulfils this purpose up to a certain point, but beyond that we find it rather disappointing. The opening portions of each chapter give an excellent general account of the matter in hand; but these are followed by a mass of minute detail which is very tedious reading. An attempt has been made to give descriptions of the more important ore-deposits of practically all countries; these are necessarily brief, and rather suggestive of rough notes made for one's own use; further, in the absence of a complete index to the volume, they are useless for purposes of reference.

The subject is treated from the point of view of genesis (which causes much repetition), the headings of the several chapters being:—

Ores due to the differentiation of igneous magmas.

Pneumatolysis.

Hydatogenesis—Deposits formed by after-eruptive actions which are not pneumatolytic.
Ores due to metasomatic replacement.
Bedded ores due to precipitation.
Metamorphic ore deposits.
Secondary changes in ore deposits apart from metamorphism.
Detrital and alluvial deposits.

The proof-sheets do not appear to have been very carefully read, and there are several shortcomings in mineralogical detail (e.g. the chemical formula of enargite is given differently in two places, and in both instances incorrectly). There is a considerable want of uniformity in the names of minerals (e. g. chalcopyrite and copper pyrites); while 'copper and iron pyrites and zincblende', 'bog iron ore', 'bog-iron ore', 'bog iron-ore', and 'bog-iron' are quite studies in hyphens. The text-figures are not well reproduced, and in many cases are not clearly referred to by their numbers in the text.

Second Appendix to the Sixth Edition of Dana's System of Mineralogy. By Edward S. Dana and William E. Ford. Pp. xi + 114. (New York: John Wiley & Sons; and London: Chapman & Hall. 1909. Price 6*s.* 6*d.*)

The indispensable sixth edition of Dana's 'System of Mineralogy', published in 1892, was brought up to date by a first appendix in 1899, and the second appendix, now issued, gives a résumé of the descriptive mineralogical literature of the last ten years. This new appendix is written on exactly the same plan as before, but, covering a rather longer period, it is proportionally longer (being 114 pages instead of 75).

The work of compilation was done by Professor Dana himself at intervals down to 1906, when, most unfortunately, owing to ill-health he was obliged to relinquish the task. We are relieved, however, to hear that he has now so far recovered that he is able to resume a part of his duties. Since 1907 the somewhat arduous work has been carried on by the junior author, who is the late Professor Penfield's successor at the Sheffield Scientific School of Yale University.

In a much condensed work of reference of this kind it is difficult to avoid errors; and, unfortunately, in the new appendix they are quite abundant. There is, indeed, not a single page in the whole volume without one or two obvious errors, and on some pages there are as many as half a dozen. A want of consistency in the spelling of the names of Russian authors and localities might be passed over, if only the names

of the minerals themselves were correctly spelt. There is considerable confusion in geographical details: Moravia and Mähren are used indiscriminately; we read of chrysoberyl 'from Smaragd, Urals', chrysolite 'from Flysch', and zircon 'from Hautefeuille' (i.e. a mineral name, a geological formation, and an author's name respectively). Mention is made of the note by Professor Goldschmidt which cleared up the confusion in the statement of the locality for iron-pyrites in the Csetrás mountains in Hungary; but on the very same page we find 'Csetras', 'Csetras mountains', and 'Csetrásgebirge'. It is curious to find a mineral, of which an analysis appeared in the fifth edition of the 'System' (1868), figuring in the new appendix as a new species ('loaisite').

Igneous rocks. Vol. I, Composition, texture and classification. By Joseph P. Iddings. Pp. xi + 464, with 130 text-figures, 2 coloured plates, and tables. (New York: John Wiley & Sons; London: Chapman & Hall. 1909. Price 21*s.* net.)

This is a companion volume to the author's 'Rock Minerals',[1] which was published in 1906. The second volume on the igneous rocks is to deal with their description and occurrence; and when this appears, we shall have a handsome set of volumes, treating the subject more exhaustively than has been hitherto attempted in the English language. If only a fourth volume on the crystalline schists and sedimentary rocks could be included in the series, something like completion would be arrived at.

Part I, on the chemical and mineral composition and constitution of igneous rocks, is divided into the following chapters: I, chemical composition, and the diagrammatic representation of analytical results. II, chemical composition of pyrogenetic minerals; here, under each chemical element in turn, we have a useful list of minerals containing the various elements, with a brief statement of the formula, percentage composition, and the rocks in which they occur. III, principles of physics and chemistry applicable to rock-magmas, in which is given an excellent account of the theory of solutions. IV, chemical reactions in rock-magmas. V, separation of substances from solution, treated from the standpoint of physical chemistry. VI, texture of igneous rocks, illustrated with an excellent series of text-figures. Here we are sorry to see the introduction of a large number of highly artificial and curiously constructed words descriptive of different kinds of texture; but as many

[1] Reviewed in this Magazine, vol. xiv, p. 416.

of these do not appear in the index, they may be overlooked and thus die a natural death. VII, differentiation of rock-magmas. VIII, modes of occurrence.

Part II, on the nomenclature and classification of igneous rocks, gives an interesting historical sketch and summaries of the qualitative or mineralogical (47 pp.) and the quantitative or chemical systems (61 pp.) of classification. Considering that the author is one of the propounders of the new quantitative system, the summary he gives of the qualitative system is most fairly stated; indeed, in no other English book do we find such crisp and clear definitions of so many rock names (together with their authors and date).

Handbook for Field Geologists. By C. W. Hayes. 2nd edition. Pp. ix + 159. (New York: John Wiley & Sons; and London: Chapman & Hall. 1909. Price 6*s.* 6*d.* net.)

The first edition of this little book was written, in 1908, specially for members of the United States Geological Survey, but the demand for it was much wider than was anticipated. The new edition has therefore been prepared for the use of field-geologists in general, though the good influence of the model survey of the United States still predominates throughout. The book is full of useful instructions and hints, and it contains detailed schedules indicating how special investigations should be carried out. It may with advantage be consulted by all field-geologists and prospectors, more particularly those in South Africa and Australia, where larger tracts of country have to be covered than at home. Amongst the numerous points dealt with there are sections on collecting and the systematic method of duly labelling specimens of rocks, minerals, and ores. As to the collecting of minerals, no very specific instructions could of course be expected, but 'the geologist should not neglect opportunities to collect new, rare, or finely developed minerals, even if they have no immediate bearing on his work'.

The volume is neatly bound in morocco, and of a size suitable for carrying in the pocket. Its only drawback appears to be its rather high price.

Crystalline Structure and Chemical Constitution. By A. E. H. Tutton. Pp. viii + 204, with 54 text-figures. (London: Macmillan & Co. 1910. Price 5*s.* net.)

This is the first volume in a new series of 'Science Monographs', which promises to be of considerable interest and utility. As clearly

stated in the preface of the present volume, the object has been to give a connected account of the author's own researches carried on during the last twenty years, the full results of which have already been published in a long series of important papers well known to chemists and crystallographers. Some indication of this object might with advantage have been given on the title-page; for only one branch of the wider subject suggested by the title is touched upon, namely, that of isomorphism, and even this is limited to the relations shown by just two series of isomorphous salts. In addition, we find descriptions of the several elaborate instruments designed by the author for his special work; some of which instruments are now finding important applications in other directions. In the historical introduction the year 1890 is repeatedly mentioned, but we cannot quite agree with the author that that year marks a turning-point in the history of crystallography.

We cannot help but admire the extreme care in observation, and the endeavours to obtain the highest degree of accuracy, displayed by the author, and express our wonder at the marvellously delicate instruments of research which, with such mechanical skill, he has designed. The present book may well serve as a model of how a carefully premeditated piece of scientific research should patiently and laboriously be carried out; and to the specialist it gives a distinctly useful summary of the rather lengthy original papers. The constants which have been so accurately determined for fifty-four different salts in the two isomorphous series are not all quoted in full in the book, and when these are wanted it will still be necessary to refer to the original papers.

Introduction to the study of minerals and guide to the mineral collections in Kelvingrove Museum. By PETER MACNAIR. Pp. 70, and 1 plate. (Glasgow, 1910. Price 3*d.*)

As the title suggests, this guide-book is modelled on much the same plan as the one written by Mr. L. Fletcher in 1884 for the Mineral Gallery of the British Museum. While the introductory portion gives a brief summary of the general characters of minerals, instead of an historical sketch, the descriptive portion is much the same, except that only the more common minerals receive mention.

Both the introductory collection and the general collection appear to be very well arranged and carefully labelled; and with the assistance of this little guide-book (which, at its very moderate price, is within reach of everybody) an attentive student should very soon acquire a good elementary knowledge of minerals. In a district like that of Glasgow,

within easy distance of which many minerals can be collected, such a collection and guide-book offer a strong inducement to boys to take a keen interest in collecting. And when once the collecting instinct has been gratified by a few good finds, a desire for a more intimate knowledge of minerals is sure to be aroused.

There are a few small points which require correction; and this applies more particularly to the text-figures, sixty-one in number, which have been very roughly traced from the textbooks.